Popular Astronomy.

Vol. XIII No. 3. MARCH, 1905. Whole No. 123.

CONSTANT ERROR IN MERIDIAN OBSERVATION.*

JERMAIN G. PORTER.

Two kinds of errors have to be dealt with in astronomical and physical measurements. The first kind is accidental error. A competent observer will use his utmost effort to reduce the magnitude of these casual deviations, which no amount of skill can entirely eliminate, to a minimum. When this is done—and poor work in the present state of science is unpardonable—the influence of such errors in an extended series of measures need not be feared. But with constant error the case is different. If every measure deviates in the same direction and by practically the same amount, the mean of a hundred observations will not necessarily give a result nearer the truth than will a single observation.

In the determination of star positions by means of the meridian circle there are two sources of error which may be classed under this head. The first affects right ascensions, the second declinations.

It has long been known that in noting the time of transit of stars over wires placed in the focal plane of meridian instruments, whether this be done by eye and ear or by the chronographic method, faint stars are uniformly observed later than bright ones. This gives rise to what is known as the magnitude equation. The value of this equation for a given observer may be found by placing screens of fine wire netting or bolting cloth over the objective of the instrument, and thus reducing the apparent magnitude of the star during its transit over a portion of the wires. In this way it has been found that the magnitude equation varies greatly for different observers. Thus from the discussion of the meridian observations of the Victoria and

* Abstract of address before the section of Astronomy at the International Congress of Science and Arts at St. Louis.

Sappho comparison stars made at many observatories in 1889, the coefficient of change for one magnitude was found to range from $0^s.004$ to $0^s.055$.

To complicate the subject still further, it appears that the change is not generally uniform throughout the range of magnitudes ordinarily observed. The retardation may be fairly constant as far as the eighth magnitude or thereabouts, but beyond that it is apt to increase much more rapidly. Moreover there is no certainty that the equation for the individual observer remains always the same. Under varying physical conditions his method of taking transits is likely to vary to some degree. It is thus apparent that the elimination of this source of constant error can not be satisfactorily accomplished by simply determining the equation of the observer once for all and applying it as a correction to his transits.

Various methods of dealing with this troublesome problem have been suggested. In some of the larger observatories a series of screens is arranged, by the interposition of one or more of which the light of the brighter stars may be reduced to that of the fainter ones. This method is, however, cumbersome. Nor is it by any means certain that the image of a bright star thus screened down will be observed in exactly the same manner as an unscreened faint star.

Another device for freeing transit observations from personal equation is the so-called registering micrometer. In the simplest form the star is bisected by a movable wire during its passage across the field of view, the motion being communicated to the wire by turning a micrometer screw, and the contacts being made automatically. A more satisfactory, though much more complex arrangement, is to have the wire driven by clock-work or small electric motor, only the fine setting being done by hand.

Still another method of accomplishing the desired result is by having recourse to photography for recording transits. With a fixed plate it is impossible to catch any but the brighter stars, and hence little help is afforded in determining the magnitude equation; but by making the plate move forward with the star and replacing the wires of the reticule by spots of light thrown at regular intervals from a fixed source, as suggested by Professor Turner, observations may be secured of stars even fainter than could be gotten with the same instrument visually.

It would seem, therefore, entirely feasible to practically free the observations of right ascension from this magnitude equation, but the means of doing so are necessarily somewhat complex and

costly. Since the highest degree of accuracy is imperative in the the present state of astronomy, meridian work must either be relegated to those well endowed institutions which can install and use this apparatus, or else some simpler way of dealing with the subject must be discovered.

Such a method I wish to propose, though it will necessarily take some years to carry it out. As the photographic work of the present and future seems likely to add to the demand for meridian determinations, I think the serious consideration of this proposal by the chiefs of our astronomical almanacs would be desirable. For what I would suggest is simply to extend the list of fundamental stars and make it include stars down to the ninth or tenth magnitudes. These stars could be freed from the magnitude equation by the methods already described. The observer would then determine his magnitude equation on each evening by simply including among his clock stars both bright and faint; or if his observing list consisted of faint stars only he could select fundamental stars of corresponding magnitude.

I am aware that this scheme would in the beginning and for a considerable time entail a vast amount of work, but I believe that the increased accuracy in transit work thus rendered possible in the future, would abundantly justify it.

The second source of error, that which affects the declinations, is the uncertainty of refraction. Living as we do at the bottom of an atmospheric ocean subject to continual ebb and flow, to violent changes of temperature, and to other mutations at which we can little more than guess, the problem of determining in every case the exact amount of deflection suffered by the rays of light from the heavenly bodies is hopeless of solution. The best we can do is to eliminate its effects as far as may be. A portion of the uncertainty introduced from this cause will no doubt be of the nature of accidental error; but I believe that constant differences of considerable amount also may be due to refraction.

If we had a perfect system of fundamental stars well distributed over the sphere, we could readily determine for any given evening the deviations of refraction from the assumed law, and thus correct our observations. The problem is to form a perfect system of declinations in the first place. It is well known that the various systems now in use by astronomers vary by a considerable fraction of a second of arc. In fact, the course of the equator around the celestial sphere is not yet accurately determined. The reason of this, so far as refraction is concerned, is not far to seek. As refraction at the zenith is theoretically zero,

the nearer to this point we make our observations, the less influence will be exerted by erroneous assumptions as to the laws of refraction. If, therefore, we wish to free our fundamental system from its effects we must establish stations in as many latitudes as possible, determining at each one the declinations of those stars which pass close to its zenith. By combining the results we shall evidently get the best possible system of declinations.

It is, of course, impracticable to carry such a scheme to anything like completeness; but as a matter of fact we find not even the slightest approach to such a distribution of observatories engaged in meridian work. In the northern hemisphere practically all the meridian work is done between latitudes 35° and 60°, and in the southern hemisphere between 30° and 40°. Here then is a zone some sixty-five degrees wide in which it is safe to say no first-class meridian work is regularly prosecuted.

The proposed establishment by the United States Navy of an observing station at Samoa, in latitude 15° south, is a step in the right direction, but a good deal more ground remains to be covered.

We have here truly a wide field for international coöperation. It is only by joining forces that astronomy can expect to adequately cope with the large problems presented for its solution. The formation of Professor Newcomb's great catalogue of fundamental stars at the request of the Paris Conference must be regarded as a most fortunate omen; and it is certainly not too much to hope that further needed work along this line will be prosecuted under the same auspices.

RECENT DISCOVERIES OF SATELLITES BY AMERICAN ASTRONOMERS.

WILLIAM W. PAYNE.

In August 1877, Professor Asaph Hall, then at Washington, D. C., by the aid of the great 26-inch refractor, discovered the two minute satellites belonging to the planet Mars. Any one who has read the account of the discovery, as prepared by Professor Hall himself, in the form of a memoir, will say that the discovery was a triumph of skill and patience rarely equalled in that line of work.

Sept. 9, 1892, by the aid of the 36-inch refractor of Lick Observatory, Professor E. E. Barnard discovered the fifth satellite

of Jupiter. This new satellite is an exceedingly faint object; it can be seen only by the largest telescopes under favorable circumstances. Its diameter probably does not exceed 100 miles. The diameters of the other well-known satellites of Jupiter are respectively, 2500, 2100, 3550 and 2960 miles. The fifth satellite, which has not yet been named, is between Io, the first, and the planet, at a mean distance from the planet of about 112,500 miles with a period of revolution of $11^h\ 57^m\ 22.6^s$. The discovery of this very faint object, visually, was the thing that brought to Mr. Barnard flattering congratulations from the ablest astronomers in the world.

The next American discovery in the line of satellites was scarcely less remarkable than others, although it was made in a different manner. Professor William H. Pickering, in 1888, began the search for new satellites in the system of Saturn with the 13-inch Boyden telescope of Harvard College Observatory. At this time he was unsuccessful. Later when the new 24-inch Bruce telescope was set up in the clear atmosphere of Arequipa in South America, the search was renewed by the aid of photography. On examining the plates taken Aug. 16, 17 and 18, 1898, Professor Pickering found short trails in the plates among the stars that seemed to involve the planet's motion. Then came a host of difficulties in the way of proving whether or not those minute trials were really those of a new satellite. One can not realize fully the intricacy of the problem who is not well acquainted with all the work that was necessary to settle the question in favor of a real discovery of the new ninth satellite of the planet Saturn.

The strange thing about this new satellite is the fact that it revolves in an orbit that is more eccentric than that of any other satellite, or even of any major planet in the solar system, and that its motion is opposite in direction to that of all the other eight satellites belonging to Saturn.

Another astonishing thing about this ninth satellite is the fact that it was never seen by the aid of the telescope until all had been learned of it that is now known about it. So difficult is it to observe visually that the largest telescopes in the most favorable conditions of seeing are necessary to see it at all. In August last at Yerkes Observatory, Williams Bay, Wis., and Professor E. E. Barnard and Professor H. H. Turner, of Oxford, England, tried to see the satellite by the aid of the 40-inch refractor, but they could not feel certain that they really saw it. If they did not see it, as far as we know, it has not yet been seen by any human eye.

The latest discovery of a new satellite to the planet Jupiter is that made by Professor C. D. Perrine of Lick Observatory, Mount Hamilton, California. This important discovery was announced Jan. 4, 1905. In the month of December, 1904, Mr. Perrine had suspected the existence of a new satellite in the system of Jupiter by his photographic study of it with the great Crossley reflector, on the nights of Dec. 3, 8, 9, 10, 1904, and on Jan. 2, 3, 4, 1905 which confirmed the discovery. We will soon have more data concerning this very surprising revelation by one of the gifted American workers in modern practical astronomy. On Jan. 4 its place was

Position Angle 269°
Distance from Jupiter 45′.

It was then approaching Jupiter at a daily rate of 45″ i. e. about 100,000 miles, in a retrograde direction. This does not mean that the motion of the satellite in its orbit with reference to its primary is retrograde, but that its apparent motion as observed from the Earth is retrograde.

American astronomers are doing well to keep up the reputation of our country for recent discovery in the interesting field of satellites belonging to the Solar System.

Professors Asaph Hall, E. E. Barnard, W. H. Pickering and C. D. Perrine have all done splendid work in these discoveries.

SOME REFLECTIONS SUGGESTED BY THE APPLICATION OF PHOTOGRAPHY TO ASTRONOMICAL RESEARCH.* II.

H. H. TURNER, D. Sc., F. R. S.

[Concluded from p. 82.]

May I now turn to one or two of the problems with which this new development of our work has brought us face to face? They are numerous and serious, and it is impossible to consider many of them, perhaps even the most important of them. One of the most pressing is the problem of rendering generally accessible the vast accumulations of material for study that have been suddenly thrust upon our attention. How are our photographs to be stored, preserved and published? Even now troubles have gathered, and time will only multiply them. It is many years since Professor Pickering drew attention to the difficulties in storing

* Address delivered by Mr. Turner, Savilian Professor of Astronomy in the University of Oxford, in the Section of Astrophysics at the Congress of Arts and Sciences at St. Louis, on Wednesday, September 21, 1904, at 4 P. M.

the photographic plates taken at the Harvard Observatory; when many thousands of photographs have been accumulated, not only the space they occupy but the actual weight of glass is an embarrassment. And there seems to be no doubt concerning the duty of accumulation. May I confess an early and mistaken view which I formulated on this matter? I reasoned thus:—The proper moment for making use of a photograph taken last night is today. It is useless to defer the examination until tomorrow, for there will then be new photographs claiming attention. Hence it is unscientific to take more photographs than can be dealt with immediately. This seemed to be a plausible argument and to show a way out of the difficulty, for if a photograph had once been adequately examined, it need not be stored so carefully, and there would not in any case be many to store. But Professor Pickering has demonstrated many times over that the view is untenable. By taking photographs almost recklessly and without any hope of dealing with even a fraction of them, he has created the possibility of tracing the history of celestial events *backwards*. When new objects are discovered he can go to his shelves and tell us how long they were visible previous to discovery; and this information is so valuable that we must certainly arrange our future plans with reference to it. It is quite certain that we must be prepared to deal with enormous accumulations of plates, to store them in proper order, and to catalogue them; and if it has already been found difficult to do this for the collection of a single observatory during twenty years, what can we look for in centuries to come?

Possibly the second difficulty, that of preservation, may be an antidote to the first. It is by no means certain that our photographs will last long; and if not, there will be a natural limit to the time during which they need be kept. Sir William Crookes has, however, reminded us that by toning them, by substituting sturdy gold for the perishable silver, we may prolong their life indefinitely, though this will, of course, sensibly increase the cost of each plate. As yet I have not heard of any toning process being systematically adopted. Our course is, however, comparatively clear in this direction; it would seem imperative that a selection of the earliest photographs at any rate should be carefully toned, so that they may be available for comparison in years as far distant as possible. Although this is a matter of detail, it seems to me to compare in importance with almost any practical question which may claim the attention of astronomers; and if some decision of the kind were the only outcome of this gathering, I think we might be well content with the result.

The question of publication is chiefly one of funds, and is only worthy of special remark because these particular funds are so often forgotten in planning enterprises. I need not labor the point, for the experience of any astronomer will supply him with plenty of instances. The difficulties of publication have much in common with those of storage; they will increase year by year, and even when the money for printing has been found, the storage of publications received from other observatories will itself become an embarrassment. There is, however, one way in which some of the stress may be relieved, namely by efficient cataloguing. If we have before us a list of all the photographs existing in the world, and know that we can send for a copy of any one of them which may be required, it is no longer necessary to have copies of all. This applies, of course, to other publications as well; and though we may take some time to grow out of the sentimental desire for a complete library, and though the existence of a few such complete institutions may always be desirable, I venture to think that many observatories will ultimately be driven to the plan of acquiring only what is certainly and immediately useful, depending on temporary loans from central institutions for other material.

But there is a class of problems differing totally in character from these practical questions of storage and preservation of plates. A period of suddenly increased activity such as we have been passing through in astronomy is not without important effects on astronomers themselves. The human element in our scientific work is sometimes overlooked and generally accorded only a subordinate importance; but coming as I do from an old university devoted to the Humanities, I may be perhaps forgiven for calling attention to a few human considerations. In the first place, I have felt some anxiety lately for that very important body of astronomers who are sometimes called amateurs, though the name is open to criticism—those whose opportunities for work are restricted to a more or less limited leisure. It is a body which is somewhat sensitive to the feeling that astronomical work has gone beyond them, that in the presence of large instruments and of the special knowledge acquired by those using them, their own efforts and their own humbler instruments are no longer of any value. If I am right in supposing that this feeling has been called into existence lately by the rapid advances made in photography, it is certainly not for the first time. At previous epochs this diffidence has found expression and has, I am glad to say, been met by careful contradiction; but it is

necessary to repeat the expostulation again and again, for the anxiety is apt to crop up with every new development of astronomical activity.

The *early* days of photography were better ones than usual for the amateur; indeed the introduction of the photographic method is largely due to the work of such men as Rutherford and Draper in America, De la Rue and Common in England. But now that we have passed beyond the stage when each new plate taken was a revelation; now that we are tolerably familiar with, at any rate, the main types of possible photographs which can be taken with modest apparatus; more especially now that we have begun to discuss in elaborate detail the measurement of star positions or of stellar spectra, the old shyness is beginning to crop up again. But it is of the utmost importance that this shyness should be zealously overcome. Perhaps, after all, it is not sufficient to assert that there is still good work for amateurs to do, nor even to mention a few instances of such work urgently required; perhaps it should be made easier for them to follow what is being done. Especially do we want more and better *books*, written by the best men in each subject. The original memoir, though it may be a proper form of publication for the workers themselves, does not satisfy all requirements. There is much to be done in the way of extension and collation before the work can be presented in a form attractive to those who would gladly keep in touch with it if the process could be made a little easier. Huxley was constantly urging scientific men that it was not sufficient to attain results; they must also express them in an intelligible and attractive form. Of course it is not easy for the same man to do both. There are few who could have determined, like Schiaparelli, that the period of rotation of the planet Mercury was 88 days instead of 1; but there are fewer still who, after making the discovery, could have given the beautiful lecture which he gave before the King of Italy, developing fully in attractive detail the consequences of the discovery; and yet it is probably true that many more could make, at any rate, an attempt in this direction, if adequate opportunity and inducement were provided. Could not a part of the sums available for the endowment of research be devoted to the endowment of text-books? It is of course an inducement to write such a book that it is a good thing well done; but in the case of a scientific worker this is scarcely sufficient, because the same could be said of his continuing his particular work. If we ask him to pause, and render the treasures he has collected accessible to others,

there must be some additional inducement. Publishers are not able to offer pecuniary encouragement, because books of the type I have in mind would not appeal to a very large public. But why should they not be subsidized? I do not think it need be a very costly business, if the money were placed in the hands of a central body to issue invitations for books to be written. An invitation would be in itself a compliment; and the actual pecuniary value of the inducement would shrink in importance, just as the actual amount of gold in a medal awarded by one of our leading scientific societies is not very seriously regarded. It may be objected that to ask the best men to write text-books is to set them to inferior work, and so to delay true scientific progress; but are we sure that the real march of science is being delayed? There are pauses in a journey which merely waste time; but there are others without which the whole journey may be delayed or prevented, as when a man should neglect to rest and feed the horse which carries him.

But the development of photography has brought with it much more than a recurrence of diffidence in some amateurs; it has fore-shadowed a serious rearrangement of astronomical work generally—a new division of labor and a new system of co-operation. To quote one notable instance: a very small number of observatories could take enough photographs to keep the whole world busy examining or measuring them, and we are already face to face with the question whether this is a desirable arrangement. Let me give a concrete example of this modern situation. In the winter 1900-1 the small planet Eros offered a specially favorable opportunity for determining the solar parallax, and some thousands of photographs were taken at a number of observatories for the purpose. It is not yet very clear how a definite result will be obtained from the mass of material accumulated, most of which is being dealt with in a very leisurely manner: but a small portion of it has been discussed by Mr. A. R. Hinks, of Cambridge, and one of the many important results obtained by him in a recently-published paper (*Mon. Not. R.A.S.*, June 1904) is this: that the plates taken at the Lick Observatory are susceptible of such accurate measurement, and so numerous, that a determination of the solar parallax from them alone would have a weight nearly equal to that from the whole mass of material. If the Lick plates can be measured and reduced, it will not much matter if all the others are destroyed. Whence we may deduce two conclusions: firstly, that it is eminently desirable that these beautiful pictures should be measured and re-

duced as soon as possible; secondly, that we must consider future plans of campaign very carefully if we are to avoid waste of work and discouragement of workers. It is tolerably easy to reach the first precise conclusion; I wish it were easier to arrive at something more definite in regard to the second. It seems clear that we may expect some readjustment of the relations between the better-equipped observatories and those less fortunate, but it is not at all clear what direction that readjustment should take. One possibility is indicated by the instance before us: the discussion of the Lick photographs was not conducted at the Lick Observatory, but at Cambridge: the price paid for the fine climate of Mount Hamilton is the accumulation of work beyond the powers of the staff to deal with, and the new division of labor *may* be, for the observatories with fine climates and equipment to take the photographs, and astronomers elsewhere to measure and discuss them. Professor Kapteyn has set us a noble and well-known example in this direction, and in view of the pressing need for a study of many photographs already taken, it is to be hoped that his example will be followed, especially in cases similar to his own, where no observatory is in existence. If in such cases the investigator will set up a measuring machine instead of a telescope, he will deserve the gratitude of the astronomical world.

But the case is not so clear when a telescope is already in existence. Mr. Hinks had a fine telescope at Cambridge, and it required some self-denial on his part to give up observing for a time in order to discuss the Lick photographs and others. If the accumulations already made, and others certain to be made in the future, are to be dealt with, this kind of self-denial must certainly be exercised, but it does not seem quite clear that it should always fall to the lot of those with a modest equipment. Considerations of strict economy might suggest this view, but there is a human side to the argument which is not unimportant. The danger that the minor observatories should feel their work unnecessary is even graver than the similar possibility in the case of amateurs already mentioned, and calls for prompt attention from astronomers generally if it is to be averted. It is the more serious because of another set of considerations of a quite different kind, viz., the funds available for research show a rather alarming tendency to accumulate in the hands of a few large observatories, leaving many astronomers who could do useful work without the means of doing it. A conspicuous example is afforded by the present state of the work for the Astrographic Chart

initiated in Paris seventeen years ago. On the one hand a few of the large observatories have easily acquired funds not only for taking and measuring the plates and printing the results, but for publishing an expensive set of charts which will be of very little use to anyone; on the other hand, some of their colleagues have found the utmost difficulty in getting funds for even taking the plates; others have got so far but cannot proceed to measure them; and a very few indeed have yet funds for printing. If there had been a true spirit of coöperation for the general good in this enterprise, surely some of the funds being squandered on the comparatively useless charts would have been devoted to the proper completion of the only part of the scheme which has a chance of fulfillment. I do not mean to imply that this would have been an easy matter to arrange, but it is noteworthy that no attempt in this direction has been made, and that as a consequence a promising scheme is doomed to failure in one important particular. For though the survey of the whole sky to the 11th magnitude may some day be completed, it will be sadly lacking in homogeneity. Some sections are finished before others are begun, so that in the vital matter of epoch we shall have a scrappy and straggling series instead of a compact whole.

Coöperation in scientific work, the necessity of which is being borne in upon us from all sides, is nevertheless beset with difficulties, and no doubt we shall only reach success through a series of failures, but we shall reach it the more rapidly if we note carefully the weaknesses of successive attempts. In the particular scheme of the Astrographic Chart, I think an error which should be avoided in future was made by those who have access to the chief sources of astronomical endowment. They have made the enterprise doubly difficult for their colleagues: firstly, by setting a standard of work which was unattainable with limited resources; and secondly by depleting the reserves which might have gone to assist the weaker observatories.

It is easier to draw attention to these modern tendencies than to suggest a remedy for them. It may, perhaps, be questioned whether a remedy is either possible or necessary; it may be urged that it is both inevitable and desirable that astronomical observation should gravitate more and more to those well-equipped observatories where it can be best conducted, and that new resources will obtain the greatest results when added to a working capital which is already large. From the purely economical point of view of getting results most rapidly, these conclusions may be true. But if we look at the human side of the question

I hope we shall dissent from them; if we think first of astronomers rather than of the accumulation of astronomical facts, I hope we shall admit that something must be done to check the excessive specialization and the inequalities of opportunity towards which there is a danger of our drifting. We cannot afford the division of astronomers into two types: one isolated in a well-equipped observatory in a fine but rather inaccessible climate, spending his whole time in observing or taking photographs; another in the midst of civilization, enjoying all the advantages of intercourse with other scientific men, but with no telescope worth using, and dependent for his material on the observations made by others. Some division of labor in this way is doubtless advantageous, but we must beware lest the division become too sharply pronounced. Will it be possible to prevent its undue growth by some alternation of duties? Can the hermit observer and the university professor take turn and turn about to the common benefit? The proposal is perhaps a little revolutionary, and has the obvious disadvantages of inconvenience and expense at the epochs of change; but I do not think it should be set aside on these grounds.

I must admit, however, that I am not ready with a panacea. It has been chiefly my object to draw attention to some modern tendencies in astronomical work, hoping that the remedies may be evolved from a general consideration of them. Such questions of the relationship of the worker to his work are even harder to solve than those we meet with in the work itself. But there is at least this excuse for noticing them on an occasion like the present, that they are, to some extent, common to all departments of knowledge, and our difficulties may come to the notice of others who have had occasion to consider them in other connections and may be able to help us. Or, again, we may take the more flattering view that the human problems of astronomy today may be those of some other science tomorrow; for astronomy is one of the oldest of the sciences, and has already passed through many stages through which others must pass. In any case we must deal with these problems in the sight of all men; and of all the consequences entailed by our lately-acquired opportunities, none are more interesting and none can be more important to us than those affecting the astronomer himself.

AN EXAMINATION OF THE MODERN VIEWS AS TO THE REAL NATURE OF THE MARKINGS ON MARS.*

GERALD H. LEPPER.

Of late years many differences of opinion have arisen as to the interpretation to be placed on the appearance of the surface markings of the planet Mars. The views which found general acceptance about the middle of the Nineteenth Century have been somewhat roughly handled by the observations made since 1877. As the latter observations have been made with telescopes vastly superior in dimensions to those employed prior to the above-mentioned year, it is only natural that present day astronomers should regard the more recent observations as forming a better groundwork to build their hypotheses on, than the results obtained by the less powerful instruments previously in use. Yet although it seems that we are approaching the limits of magnifying power of the optical instruments at present known to science, it cannot be doubted that we are even now far from seeing planetary detail in anything like its real form, and, therefore, so long as we can perceive only the general effect of the *ensemble* of the actual markings on the disc of Mars, it appears to be more than a little rash to be over confident in attempting to interpret minute detail, which we do not see in its undisguised and natural state.

But be that as it may, numerous hypotheses have been formulated in attempts to explain the nature of what we see on Mars, and the time appears to be opportune for an examination of some of the more generally accepted views. Perhaps it will be advisable to commence with the yellow-ochre portions of the Martian surface which have been, and still are, almost universally regarded as land.

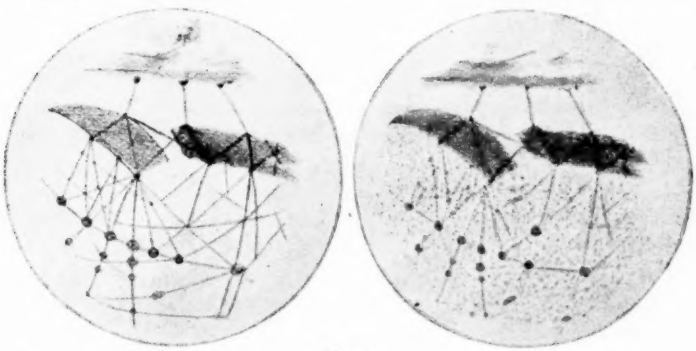
Until Schiaparelli started discovering the "canals," the popular view was that the ruddy regions of the disc could be safely regarded as continents, and their tint was ascribed by some to the density of the Martian air, whilst others hazarded the opinion that the vegetation on Mars might be of a ruddy yellow tint instead of green as with us. The first explanation was swiftly disposed of, since the central portion of the disc appeared redder than the regions near the limb, which would not be the case if the cause of this appearance lay with the Martian atmosphere.

* *Journal British Astronomical Assocaition* XV, 3.

The red vegetation idea has been superseded to a great extent of recent years by the explanation given by Mr. Lowell, viz., that the areas in question are deserts pure and simple. These opinions will, however, be considered later on.

Returning to the "canals" and their kindred phenomena the "oases," which form the most striking and characteristic appearance of any modern map of Mars, we find astronomers divided into two principal camps. The first, or artificial construction party (which is headed by Mr. Lowell) believes that the "canals" are strips of vegetation on either side of a watercourse constructed for the purpose of conducting the water, annually set free by the melting of the polar snows, to the oases, which are to be found scattered all over the "desert" areas. The other group maintain that the "canals" are in reality nothing of the sort being, (1) Edges to faint shades which appear dark by contrast with the brighter area which they adjoin; (2) Optical illusions induced by the contour of various markings, also by the tendency of the eye to join up to spots or similar objects with a straight line, where in reality none exists; (3) The effect on the eye caused by the aggregation of minute detail, which is not large enough to be visible in its true form. The experiments made last year by Messrs. Maunder and Evans (see "*Monthly Notices*," Royal Astronomical Society, June 1903), have proved that the above explanations will explain most of the canaliform markings seen on Mars.

Take figure 1 for example. This is a copy of a view of Mars given on page 103 of Mr. Lowell's clever contribution to our Areographic literature, entitled "Mars." The longitude of the



MARS.

Fig. 1. From Lowell's "Mars", p. 103. (Longitude 180° Central.)

Fig. 2. The same region as it may appear under higher magnifying powers.

central meridian is 180°. Figure 2 shows the same region as it might possibly appear under a much higher magnifying power. While we have a simple and not improbable explanation of these strange markings close at hand, it is clearly going out of our way to attribute them to the inhabitants of the planet, and, although it is more than probable that Mars is, or has been, inhabited by beings as high as, or even higher than, ourselves in the scale of intelligence, it savors somewhat of sensationalism to perceive the traces of such intelligence in markings which, on closer inspection, would probably resolve themselves into something not at all artificial in appearance.

Before continuing to discuss the problem presented by the ochre-colored regions, it is necessary that the water question should receive some attention.

Just as the lighter regions were formerly supposed to be land, so the blue-gray areas of the disc were thought to be the seas and oceans of the planet. Since about ten years ago, much doubt has been cast on this view, the artificial canal party holding that, instead of being water, these areas are the old sea beds which are now occupied by a semi-permanent vegetation, and that the narrow blue zones, seen to surround both the polar snows at their annual melting, are the only bodies of water of any extent on the planet. Let us see what their reasons are for denying the aquatic character of the other dark markings. Firstly, because the bands surrounding the polar snows are the only dark areas whose light shows traces of polarization; secondly, because the seas vary much in tint; thirdly, because "canals" have been seen in the dark regions as well as in the continental masses.

As for the first reason, it seems quite possible that it is the adjoining ice cap which polarizes the light of the polar seas, and that in reality *none* of the Martian seas show any trace of polarization. With regard to reason No. 2, the effects of contrast are again evident in this case, causing the coast lines of the seas to appear darker than the central portions, whilst the latter appear very faint. It is very probable that Cimmeria, Scheria Insula, and similar islands, are in reality nothing more than contrast effects. Again, the unevenness and variation of tint is doubtless intimately connected with the depth of the seas at different points. A difference in color between some of the oceans of the Earth is very noticeable; the water at Madeira, for instance, is quite a different shade to that on the English or South African coasts, being a much deeper and more beautiful blue. Obliquity of illumination may also have something to do with

difference in tint, but, whatever the cause, it is an undeniable fact that differences exist on this planet and there is no reason why similar effects should not be visible on Mars. The white wave crests too would, no doubt, have an appreciable speckling effect in the aggregate. It must also be remembered that we do not as yet know the mass of the inner satellite of Mars, and that it is quite possible that this Moon may be large enough to cause appreciable tides on its primary, whilst its rapid rotation would cause the Martian seas to be violently agitated, and this may explain the absence of any polarization of the light reflected by them. The presence of light semi-transparent fogs, over portions of the seas, would also have the effect of making them appear faint, and, as the temperature at the surface of Mars seems to be fairly high, it is reasonable to suppose that low-lying fogs and mists are of frequent occurrence. As for the "canals" in the dark regions, it is possible that they are illusions pure and simple, caused by the eye joining up various spots with dark lines. Possibly some of them are currents similar to the Gulf stream.

But the presence of the polar caps seems to afford the most convincing proof that other bodies of water exist on the planet. For if, as Mr. Lowell suggests, the melted polar ice is immediately made to spread itself all over the "oasis" system in the ochre areas, by means of irrigation channels, it does not seem probable that any quantity of it would find its way back again to the poles during the winter, since it would be practically all used up in fertilizing the "oases," and the strips of cultivated land along each channel. Since, however, as much water finds its way back to the pole as leaves it, it is hard to see how we can avoid admitting the existence on the planet of large bodies of water, the evaporation from which travels towards the nearest pole during the autumn and winter and is deposited there, forming a polar cap analagous to our own, though not nearly so deep. That the actual quantity deposited is small compared with the polar ice masses of the Earth, is proved by the extent to which the Martian polar snows melt in summer. In 1894 it seems that the southern ice cap melted completely.

Returning to the continental regions. Are they desert, or is the vegetation of a ruddy hue? The canaliform markings and "oases" which are probably the more conspicuous details, and, in fact, the only ones visible to us, of what is possibly a very chequered surface, ought to effectually dispose of the desert theory. There remains the ruddy vegetation view. Now it seems that the ruddy hue of the Martian continents is most

striking in small instruments, and that in larger ones it becomes a sort of yellow-ochre tint. This tint exactly describes the appearance of the South African veldt in winter (the dry season). The long rank grass becomes a yellowish brown hue, and, where it is not burnt annually, it retains this appearance all through the year. After being burnt it comes up green when the spring rains have fallen, and remains so through the summer, turning brown in the autumn. It is, therefore, by no means impossible that the Martian continents are covered with a similar type of vegetation, which retains its brownish tint (slightly reddened by contrast with the bluish green areas) throughout the Martian year; and that the "oases" and "canals" are merely patches of wooded country of greater or less extent, such as are found on the South African veldt, and which, at this distance, give us the impression of a wonderful canal system.

In the present state of our knowledge these views appear to be at least as probable as those held by Mr. Lowell, with, however, this advantage, that they do not require the assistance of a race of Titans to explain the existence of stupendous engineering feats.

MARITZBURG, NATAL, SOUTH AFRICA.

November 13, 1904.

THE SOLAR ECLIPSE OF AUGUST 30, 1905, AS VISIBLE IN THE UNITED STATES.

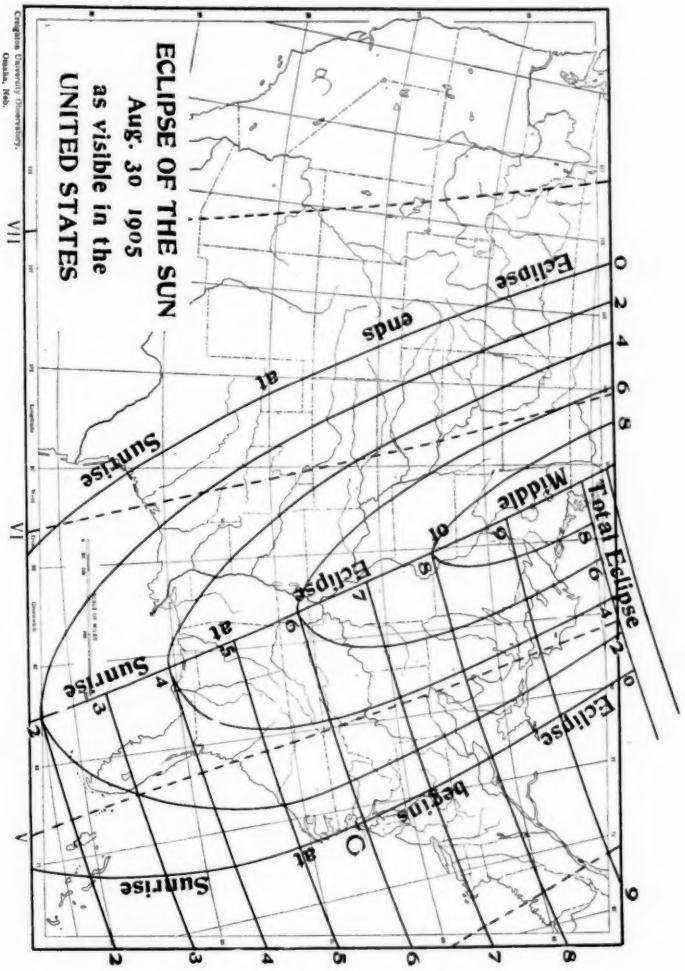
WILLIAM F. RIGGE, S. J.

FOR POPULAR ASTRONOMY.

The solar eclipse of August 30, 1905, is, as is well known, a total eclipse. But as the path of totality begins just outside of the United States, the eclipse becomes for us a partial one and occurs near the time of sunrise. A map of this eclipse specially constructed for the United States which will show the varied degrees of obscuration attained in the different states, will therefore, I trust, be of interest to the reader, and it is accordingly given herewith. This eclipse map was constructed graphically according to the method explained by the writer in POPULAR ASTRONOMY Nos. 32, 33, 34, of August, September, October 1896.

A great part of the sunrise oval lies across the United States. Its eastern branch entitled "Eclipse begins at Sunrise," its middle line showing the "Middle of the Eclipse at Sunrise," and its western branch on which the "Eclipse ends at Sunrise," are sufficiently intelligible not to need any explanation. The smaller

ovals marked 2, 4, 6, 8, show the even tenths of obscuration, that is, of the Sun's diameter obscured, at the moments of sunrise. For example, all along the oval 6 the Sun rises six-tenths



eclipsed, along the eastern branch of this oval the eclipse is increasing and along the western branch decreasing at this moment.

The system of lines approximately at right angles to the middle of the eclipse line, denotes every tenth of obscuration for the middle of the eclipse, or in other words, the maximum obscuration.

A couple of examples will illustrate the use of the eclipse map. At Cincinnati, Ohio, the Sun rises with an obscuration of 0.50, and this increases to 0.67. At Omaha, Nebraska, the obscuration at sunrise is 0.56 and is diminishing.

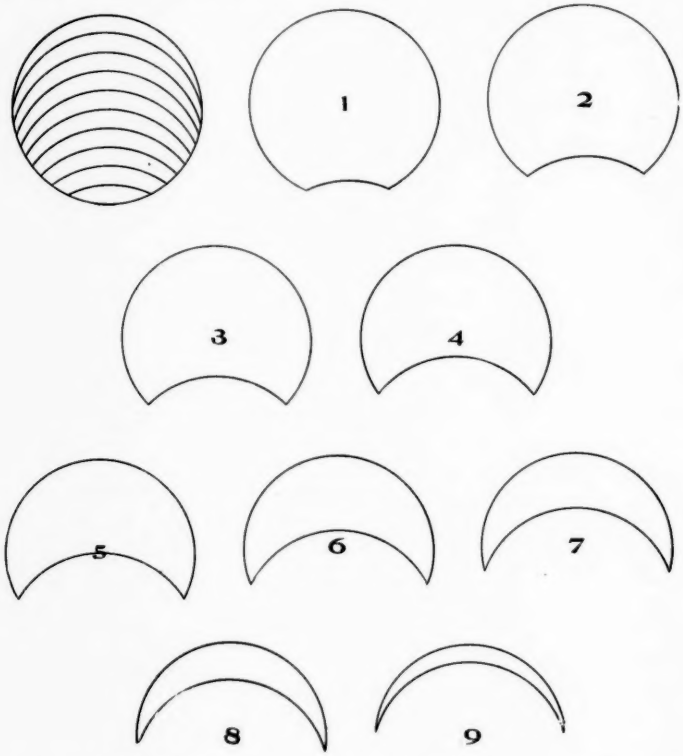


FIG. 2. THE SUN AS VARIOUS TENTHS OF ITS DIAMETER ARE OBSCURED.

The dotted lines marked V, VI, VII, at the bottom of the map, show the places at which sunrise occurs at 5, 6, 7, o'clock, Central Time. C is the point of First Contact.

Fig. II. shows the appearance of the Sun as various tenths of its diameter are obscured.

CREIGHTON UNIVERSITY, OBSERVATORY.
OMAHA, Nebr.

THE APPROACHING OPPOSITIONS OF MARS.

ROBERDEAU BUCHANAN.

FOR POPULAR ASTRONOMY

The ephemeris of Mars 1909, which I have just finished calculating for the *Nautical Almanac*, (my twenty-fifth year,) will doubtless interest POPULAR ASTRONOMY readers, since at the coming oppositions of Mars 1905-7-9 the planet will be successively nearer to the Earth, until the latter year is reached when the planet will be nearer than at any other opposition for fifteen years to come. 1911 will be less favorable but it will be more so than 1905.

The synodic period of Mars is two years and fifty days, so that each successive opposition will be fifty days later in the year than the previous; the interval varies however on account of the great eccentricity of Mars' orbit; The opposition may fall only a month and three or four days later, or at other times two months and a half. The longitude of Mars' perihelion is 334° 13′ when the planet is nearest to the Sun and consequently also to the Earth's orbit. If the Earth should be in this longitude at the same time, the opposition would be the closest possible.

The circumstances of the three approaching oppositions are shown as follows:

OPPOSITIONS OF MARS.

Year.	Mars passes Perihelion.	Opposition.	Distance from Earth.	Brilliancy.
1905	Nov. 7	May 8	0.543	36.8
1907	Sept. 22	July 5	0.411	75.4
1909	Aug. 13	Sept. 25	0.390	86.6

The approximate distances from the Earth at the time of oppositions are here given in natural numbers so that they can be the more easily compared; they are rapidly changing, however. The unit is the Earth's mean distance from the Sun. It will be noticed that at the last date given, Mars passed its perihelion *before* opposition so that every two years after, the least distance of the planet from the Earth will be increasing until the aphelion is passed.

It may be interesting to note the brilliancy of Mars at previous oppositions. These values are:

1901, 20.0; 1903, 23.4.

The brilliancy of Mars was not given in the *Nautical Almanac* before these dates. Newcomb's new Tables being first used for the ephemeris of 1900.

The next close opposition of Mars will occur after fifteen years, and *before* the planet reaches its perhelion which was the case in 1892; the next following after that will occur after seventeen years and *after* the planet has passed its perihelion, as in the year 1909. These close points it is seen alternate before and after the perihelion passage; and the successive times are also alternately fifteen and seventeen years.

THOMAS WILLIAM WEBB.

ARTHUR MEE.

FOR POPULAR ASTRONOMY.

In the churchyard of a quiet village near the old and historic town of Monmouth lies all that is mortal of one whose name is a household word with every astronomer of the English-speaking race. Passing through the lich-gate, near which still stand the stocks, we see on the right as we approach the church a plain horizontal slab bearing the following inscription:—

TO THE DEAR MEMORY OF
THOMAS WILLIAM WEBB, M. A.,
Vicar of Hardwick, Hay, and Prebendary of
Nonnington, in the Cathedral of Hereford,
Who died May 19, 1885,
Aged 77 Years.
Also of
HENRIETTA MONTAGU WEBB,
His Wife,
Who died Sept. 7, 1884,
Aged 68 Years.
Sleeping in the love and tender pity of Christ.
Jesu, Mercy.

The lettering has already begun to decay and I fear will soon be obliterated; but in his "Celestial Objects for Common Telescopes" Thomas William Webb has left behind him a lasting memorial.

The subject of this short notice was the son of the Rev. John Webb, an English antiquary, sometime vicar of Cardiff and afterwards rector of Tretire in the county of Hereford. His son was born Dec. 14, 1807, was educated first by his father and afterwards at Magdalen College, Oxford, where in 1829 he took his degree with mathematical honors. For many years after his ordination he was curate of Pencoyd, and later was preferred to the living of Hardwick on the Welsh border where he labored till his death in 1885. Deep as was his interest in science Mr. Webb

never neglected the duties of his parish, and his friend the Rev. T. E. Espin, F. R. A. S., has left a beautiful picture of him in this connection:—"Setting out early in the afternoon with a knapsack laden with all kinds of little comforts for the sick he would walk with vigorous stride up the hills to see some distant parishioner, and converse all the way, handling the most difficult topics with keen logical ability, at the same time with the most unassuming humility and deference to the thoughts of others. And then when the cottage was reached there was no mistaking the warmth of welcome and the smile of pleasure with which he was received. And there he would sit, the children gathering round him, and talk to his people of their every-day life and local matters, making himself one of themselves, and imparting the sunshine of his life to theirs."

Mr. Webb was quite a youth when he first began to take an interest in astronomy and to make observations for himself. His first telescope was a 4-inch fluid achromatic of which he quaintly remarks that "much of the light went the wrong way." This was replaced by a $3^{7}/_{10}$-inch of 5 feet focal length by Tulley "of fair defining quality." In 1859 through the advice of his friend the well known observer Rev. W. R. Dawes he obtained a 5½-inch object-glass by Alvan Clark which he mounted and used with effect for a number of years. Then came G. H. With and his fine silvered glass reflectors. One of these of 9⅓-inch aperture was mounted in 1866 and remained Mr. Webb's principal telescope up to the time of his death when despite its excellence and its honored associations it was sold for a mere song. This telescope stood in a little Berthon observatory a few yards from the Vicarage front door. Mr. Webb was an enthusiastic admirer of Alvan Clark as a maker of achromatics and of With as a maker of silvered glass reflectors, and he had no small share in laying the foundation of the subsequent popularity of the reflector amongst English astronomers.

As we have said Mr. Webb commenced observation in the twenties. His first recorded observation was made in 1834, his last in 1885, his active life as an observational astronomer thus covering a period of fifty-one years. His principal observations are contained in four large manuscript books all most neatly and beautifully kept and illustrated with many exquisite drawings. Many other note-books are also in existence, dealing with every phase of science and natural history, for Mr. Webb was a born observer taking the deepest interest in everything around him. "Everything in nature had a charm for him" writes Mr. Espin, to which

remark Mr. Webb's remains published and unpublished bear the amplest witness. He was a voluminous and delightful correspondent and the "guide, philosopher and friend" of hundreds who had never looked upon his face. Were the writer an accomplished astronomer or a mere beginner it was all the same; and if all the letters on scientific subjects written by Mr. Webb could be collected and published they would make one of the most charming and entertaining volumes ever given to the world.

Mr. Webb wrote numerous articles for the scientific press; he was of course a frequent contributor to the "*Monthly Notices*" of the Royal Astronomical Society; and he published several books. But his fame rests on "Celestial Objects for Common Telescopes," with a few words about which this short and inadequate article must close. Up to the appearance of "Celestial Objects" English observers had no text-book suited to their needs except the "Celestial Cycle" of Admiral Smyth; but as the late Captain Wm. Noble well put it, where Smyth addressed scores Mr. Webb addressed hundreds, perhaps even thousands; and it can hardly be denied that he did more than any other writer of his day to foster a taste for observational astronomy in England.

The first edition of "Celestial Objects"—dedicated to Admiral Smyth "in due acknowledgement of indispensable assistance"—appeared in 1859, and soon established itself without a rival in its particular department. It did not differ greatly in style or appearance from the three later editions, save that the latter were considerably enlarged. After the author's decease a fifth edition in two volumes, was issued in 1893 under the editorship of Mr. Espin assisted by other competent astronomers. The grace and culture exhibited in "Celestial Objects" are as marked as its fertility and accuracy of observation. It is a book for the amateur's fireside as well as his observatory; a book that warms and elevates the heart while it clears and illuminates the mind; a work that few indeed beside its author could have given to the world. It will not be without interest to American readers to add that S. W. Burnham, the greatest living double-star observer, attributes the inception of his career to "Celestial Objects for Common Telescopes."

VELOCITY OF COMETS.

JOHN B. WOOD.

FOR POPULAR ASTRONOMY.

In mechanics, from Calculus, with which we are not to meddle,

we have an equation, which we will call the equation of straight line fall; thus:

$$v^2 = 2gr \left(1 - \frac{r}{a} \right)$$

When a is infinite, $\frac{r}{a}$ becomes o, and $v^2 = 2gr$. In this second case g is gravity, at r distance from the center of the Earth, both expressed in miles. And extracting the square root gives velocity in miles a second, after a fall from an infinite distance a, in a straight line; r, of course, being the radius of the Earth.

But the equation is true for any relation of r to a, outside the Earth. That is, for a fall from *any* height to *any* such point, in the straight line to the center, which explains why we may call it the equation of straight line fall.

We will assume an ellipse to be a straight line where the foci are at the ends of the major axis, and where the minor axis has become o. Therefore we can use the above, in the first form, for an ellipse, writing $2a$ for a in the ratio; because $2a$ is the conventional expression for major axis. (It will be noticed that $2a$ does not in this case measure height *as from the center*; in aphelion, r would measure that.)

The relations so obtained in the case of the Earth can evidently be generalized. Let us write, for the case of the Sun, our letters in capitals.

Velocity in an Elliptical Orbit is found from the following equation, which we call (A):

$$\text{(A).} \quad V^2 = 2GR \left(1 - \frac{R}{2A} \right)$$

We observe that a Parabola is an Ellipse whose major axis is infinite. For Parabolic Velocity squared we have:

$$\text{(B).} \quad V^2 = 2GR.$$

The Circle is an Ellipse whose pairs of distances are equal, $R = A$; hence $1 - \frac{R}{2A}$, becomes $\frac{1}{2}$. Write K for V:

$$\text{(C).} \quad K^2 = \frac{V^2}{2}.$$

The square of Velocity in a circle is $\frac{1}{2}$ of the squared parabolic for the same distance.

These three equations are not however manageable; we would require to find the value of G in miles a second, each time for a different R.

We will start with the case of the Earth in its orbit, treated as a circle.

From geometry, if K is the chord of a very small arc, it practically equals it. But the whole circle is 365.2564 times 86400 seconds. The travel in the arc in one second of time is then equal to the chord. The circumference in miles (radius as 92.8 million) is divided by the seconds; giving, (say) 18.48 miles. Then, by geometry: $\frac{K}{2R} = \frac{s}{K}$; ($s$ is the space, on the diameter, fallen through in one second; and equals $\frac{g}{2}$, half of gravity at the distance; whence $K^2 = \frac{2gR}{2}$. Notice that this corresponds with our inference from the Equation A. Therefore the square of Parabolic Velocity for the Earth's distance $= 2gR$; or some 682.75; whence Parabolic Velocity for the Earth's distance 26.13. This will be represented by F. Using the Earth's distance as 1, U for Parabolic Velocity, E for Elliptic, K for Circular, we can finally write the following equations:

(1). $U^2 = \frac{F^2}{d}$, (2). $E^2 = \frac{F^2}{d}\left(1 - \frac{d}{2a}\right)$, (3). $K^2 = \frac{U^2}{2}$

The d and $2a$ are in times Earth's distance; $2a$ is the major axis of the Ellipse.

Examples of the use of the foregoing.

A Parabolic comet is .01 from Solar center; what is its speed?

By (1) $U^2 = 682.75 \times 100 = 68275$; $\sqrt{68275} = 261.3$ miles a second. The real distance 928 thousand.

At what distance would a Parabolic comet have the speed of one mile a second?

(1). $U^2 = 1$, $d = \frac{682.75}{1}$, 682.75.

What is the major axis of an Ellipse if the speed at 10 (distance) is 6 miles a second?

From (1) and (2) combined: $\frac{E^2}{U^2} = 1 - \frac{d}{2a}$ or $\frac{2a - d}{2a}$; whence finally, $\frac{dU^2}{U^2 - E^2} = 2a$; this, as $U^2 = \frac{F^2}{d}$, becomes $\frac{F^2}{U^2 - E^2} = 2a$. U^2 for 10 is 68.275. We write then $\frac{682.75}{68.275 - 36} = 2a$. That is we divide 682.75 by 32.275. Use logarithms. The major axis is in excess of 21.

There is an Elliptic comet at a distance of 324, the major axis is 900; what is the speed?

Use the ratio $\frac{E^2}{U^2}$ as above mentioned: 900 — 324 gives 576; and $\sqrt{\frac{576}{900}}$ gives $\frac{24}{30}$ or $\frac{4}{5}$. In interpreting this it must be remembered that $\frac{E^2}{U^2}$ is a ratio. We must find U for 324 . . . . $\frac{26.13}{18}$, E is $\frac{4}{5}$ of this, 1.161⅓ miles a second. This is really a high rate of speed at such a great distance from the Sun.

These formulas will answer many curious inquiries.

UTICA, N. Y., Jan. 1905.

THE NEW YEAR'S EVE TELEGRAPHIC TIME SIGNALS SENT OUT BY THE U. S. NAVAL OBSERVATORY, WASHINGTON, D. C.

"The following abstract of reports received regarding last New Year's Eve telegraphic time signals sent out by the U. S. Naval Observatory at Washington has been furnished by the Superintendent, Rear-Admiral C. M. Chester, U. S. N.

The signals were sent out, as usual, for five minutes ending at midnight, 75th meridian time, and again at 1, 2, and 3 A. M., and they were given wide distribution by the Western Union Telegraph Company and its connecting lines, the Central and South American Telegraph Company, and the Government Service of Canada; by the Postal Telegraph and Commercial Pacific Cable Companies and their connections, the Canadian Pacific Railway Telegraph Department and British Pacific Cable Company; and by the American Telephone and Telegraph Company.

The Western Union Telegraph Company made a strong effort to persuade the British Post Office Department, the Great Northern and the Eastern Extension and Australasian Companies to take up and pass along the signals, but they felt obliged to decline on account of the pressure of business.

The following telegraphic reports are quoted in full:

Cordoba Observatory, Argentina: "Signals at $43^m\ 20^s.1$, at $21^s.0$, at $24^s.3$, at $19^s.5$."

(As the time is $43^m\ 20^s.1$ later than 75th meridian time, these figures show a delay in transmission of $8^s.3$, $9^s.2$, $12^s.5$ and $7^s.7$, giving a mean of $9^s.42$ late.)

Rio Janeiro Observatory, Brazil: "Rio reported received 2 A. M., signal at $4^h\ 7^m\ 10^s.4$, Rio meridian time, and 3 A. M. signal at $5^h\ 7^m\ 5^s.4$, approximately."

(Assuming Rio time to be $2^h\ 7^m\ 18^s.6$ later than 75th meridian time, the signals appear to have been received $8^s.2$ and $13^s.2$, or a mean of $10^s.7$ too early.)

Quito Observatory, Ecuador: "Please advise Naval Observatory, Washing-

ton, that first series of New Year's Eve signals reached Quito Observatory in 8 seconds."

National Observatory, City of Mexico: "All signals received perfectly via Galveston, 0ˢ.64 slow. Please accept our best wishes and greetings."

Sydney Observatory, Australia: "Sydney Observatory reports, leaving out second series, the mean time of transmission of final signals is 2ˢ.96 and says that the rapid time in sending the great distance separating Sydney and Washington, over 12,000 miles, is a triumph to the electrical departments of the states concerned."

Observatory of McGill University, Montreal: "The mid-night series of time signals over Canadian Pacific Railway telegraph wires received perfectly. Time as received corresponded with our standard clock precisely. With best New Year's greetings."

Toronto Observatory, Canada: "Signals received exactly in coincidence with our clock-beat. All compliments of the season from Toronto Observatory and the Canadian Weather Bureau, Toronto."

Aberdeen Observatory, Canada: "The members of the Hamilton Astronomers Society send New Year's Greetings to their friends in Washington. Beat tallied exactly with Hamilton observations."

The following are brief abstracts of reports from a few American Observatories:

Chamberlin Observatory		0.20	early.
Goodsell Observatory		0.06	late.
Harvard College Observatory,	First Series	0.14	early.
	Second Series	0.19	"
	Third Series	0.18	"
	Fourth Series	0.18	"
	Mean	0.17	"
Laws Observatory	First Series	0.63	"
	Second Series	0.67	"
	Third Series	0.60	"
	Fourth Series	0.58	"
	Mean	0.62	"
Mare Island Navy Yard Observatory		0.53	"

Lick Observatory, after making complete preparations to receive and time the signals, was unfortunately cut off in some unexplained way and failed to get them. Reports have not yet been received from Honolulu, Midway, Guam and Manila.

It is regretted that the cable companies in the far east were too busy to pass the signals along, as they might easily have been sent around the world in very quick time and thus have served not only a sentimental interest but a very practical one by means of their tendency to increase interest and appreciation everywhere in the universal adoption of standard time and longitude based upon the meridian of Greenwich. The transmission of the signals from Washington to Australia in less than 3 seconds, and to Argentina in less than 8 seconds, seems to show that, in spite of the many human relays that are still necessary

on long cable lines, these time signals may yet go around the world in 10 or 15 seconds.

The popular interest in these special international time signals, as they may be called, and the public-spirited coöperation of the various telegraph and cable companies and observatories, are very highly appreciated by the U. S. Naval Observatory."

After reading the above report concerning the New Year's Eve special time signal, kindly furnished us by Supt. C. M. Chester of United States Naval observatory, the reader may wonder why this last special telegraphic time signal was not more general, as compared with each of the other two which have been fully reported hitherto in this publication.

Rear-Admiral Chester very thoughtfully gave us information on this point in the following letter, which so well and so considerately sets out the present situation that we give it in full below. The reader will understand that Col. Clowry, President of the Western Union Telegraph Company, would naturally be the officer in the United States who would make the arrangements with other important telegraph and cable companies for the purpose of simultaneous coöperation in sending out such a time signal to all parts of the world; and for similar reason, we suppose, Commander J. M. Robinson, the senior officer present would make the reply, which is a very strong one for the position taken by the U. S. Naval Observatory. [EDITORS.]

January 16, 1905.

MY DEAR SIR:—

I beg to acknowledge the receipt of your telegram of the 31st ultimo, as follows:

"I regret to advise you that all our connections on the other side have declined to handle the midnight signals. The British post office department bases its refusal on the fact that no scientific purpose is served in transmitting the signals and that they so recently arranged similar special service. Great Northern Company claims necessary arrangements upset ordinary service to an extent out of all proportion to the interest in the signals. Eastern Company states that while always ready to coöperate in sending occasional messages to meet any public requirement they do not feel justified at this time in setting apart cables for the transmission of the signal. This of course will also prevent us from completing return of the midnight signal as proposed in your message yesterday."

The thanks of this observatory are due and are heartily extended to your company for your cordial voluntary coöperation in transmitting these special New Year's Eve telegraphic time signals over all your lines and in the effort to secure the coöperation of your foreign connections in bringing them back westward from Adelaide, Aust., which they reached from the east via Vancouver and the British Pacific Cable.

In so doing I feel that you have shown a broad-minded and public-spirited appreciation not only of the general popular interest in these signals, both as a

matter of sentiment and as illustrating the perfection and accuracy of our time service, but also of their value in connection with the general adoption everywhere of standard time and longitude based on the prime meridian of Greenwich.

The occasional transmission of such international time signals, sent out on the exact hour of 75th meridian time and which are of course due within at least a very few seconds of an exact hour wherever Greenwich standard time is used, must necessarily aid powerfully in calling attention to the advantages of a common standard of time and longitude and in strengthening sentiment in favor of what has been well called the Universal Time System.

It would seem that telegraph and cable companies, above all others, must realize the advantages of international standard time and assist us in the effort to force its general adoption by illustrating its advantages for international use. Already 35 nations have adopted standard time within their own limits, and 19 of these base their systems on the international or Greenwich meridian, while no two others agree together. It seems well worth the effort to bring these 19 into line with the rest, and the farther our New Year's Eve and other special time signals go, the sooner this result will be attained. It will bring with it, also, the adoption of the Greenwich meridian for all charts and sailing directions, a thing devoutly to be wished by all navigators and geographers.

I would not of course wish the Great Northern or the Eastern Company to injure their service to the extent that they seem to fear, now that their lines are so busy, but venture to hope that upon some future occasion they may be able to coöperate with us, in view of the interest that Anglo-Saxons, even more than the rest of the world, must feel in the adoption and use everywhere of Greenwich time and longitude.

As regards the point made by the British Post Office Department, that no scientific purpose is subserved by the plan inaugurated by this observatory, something should be said lest the statement, evidently made by advice of some scientist, be assumed as correct if allowed to go uncontradicted. The Post Office Department, engaged in an essentially practical business, would hardly have been expected to base its refusal on scientific grounds to a plan that is so eminently practical in its purpose as the international standardization of longitude and time. Its authorities must be aware, moreover, of the practical value of the various telegraphic longitude determinations that have been made all over the world, and of the efforts from time to time to link together various accurate but isolated surveys and thus complete the geodetic survey of the globe. In such work, in which American naval officers have taken a leading part, it has always been difficult to avoid errors due to this very use of different prime meridians by different nations, and certainly a very practical as well as scientific result will be obtained when all nations adopt the same common standard.

It seems appropriate, in view of the part that the government and people of the United States have taken in such work already, that they should continue to do all they can, even indirectly, toward its perfection and completion, but it is remarkable that the British Government Post Office Department should be less appreciative of it than private business corporations such as the Western Union Telegraph Company, the Postal and Commercial Cable Companies, the Mexican and Central and South American Telegraph Companies, and the British Pacific Cable Company, all of which, at their own expense of time and effort, have cooperated so energetically and effectively. I am glad to be able to add, however, that the Government Telegraph System of Canada, Australia and New Zealand have not hesitated to coöperate with us to the full extent of their power, and

that the leading observatories all over the world seem to think the plan of sufficient scientific interest to assist in every possible way.

Thanking you again for your kind and valued assistance, I am,

Very respectfully yours,

(signed) J. M. ROBINSON,
Commander, U. S. N.,
Senior Officer Present.

COL. R. C. CLOWRY,
President, Western Union Telegraph Co.,
New York, N. Y.

RECENT STUDIES OF THE SOLAR CONSTANT.*

A study of the solar constant and the absorption of solar radiation within the Earth's atmosphere is now being actively pursued by many scientists. Professor Langley, Secretary of the Smithsonian Institution in Washington, has probably gone farther into this line of research than any other American investigator. He led an expedition to Mount Whitney in 1881, for the purpose of securing observations on the summit of a mountain, where he expected to avoid the disadvantages that usually must be met with in the lower atmosphere. Langley's report upon these observations may be found in Signal Service Professional Papers No. 15. The results of his later studies, which are being carried on at the Smithsonian Astrophysical Observatory in Washington, have appeared from time to time in Nature and the Astrophysical Journal. The solar constant is the amount of solar radiation received outside the Earth's atmosphere, all of which would practically reach the surface of the Earth, did not the terrestrial atmosphere exist. In order to determine the constant, the effects of atmospheric absorption must in theory be eliminated, since only after the actual interposition of this do we receive the heat. It is practically impossible to secure measurements that are absolutely exact, but the relative values are very important. Langley believes that a chief cause of possible variability of solar radiation is in the solar envelope itself, as we receive heat and light through different thicknesses of it. The variability of our own atmosphere largely interferes with our study of the Sun. Langley measures the total radiation by the actinometer, and the intensity of the homogeneous rays in different parts of the spectrum for different altitudes of the Sun by the bolometer. From these direct observations he calculates in

* The accompanying extract is from an address by Henry J. Cox delivered before the Earth Science Section of the Central Association of science and mathematics' teachers Nov. 26, 1904.

theory the total absorption of the atmosphere of the several rays under the varying conditions, but on account of the constant fluctuation of the atmosphere the absorption is continually changing, and it is difficult to discriminate between any change due to it and that due to an actual change in the radiation of the Sun itself. Langley estimates that with the actinometer it is possible to secure relative values of the total solar radiation at the Earth's surface within 2 per cent, but that the absolute results may not be within 20 per cent of the truth. He therefore concludes that the values secured should not be regarded as absolute measures of the solar radiation, but only as forming a series comparable among themselves, from which all known terrestrial variations are excluded and which may furnish evidence of a suspected variability of the so called solar constant. Langley has taken as a provisional value of the solar constant, 2.54 gram calories per sq. centimeter per minute, and later investigations impressed him with the belief that it was sufficiently large. In fact his maximum during 1903 was only 2.28 calories in February, and this fell to a minimum of 1.93 calories in August. His observations also show a falling off in the transparency of the atmosphere in 1903 and this tended to reduce the intensity of the violet end of the spectrum. Very little change in the clearness of the atmosphere alters decidedly its transparency for some wave lengths. In the morning hours the transparency of the air increases rapidly and sometimes irregularly, while in the afternoon it continues longer of nearly uniform and maximum transparency. The greatest measurement is reached shortly after noon. Of course, it is more difficult to secure values of the solar constant at stations near sea level than at high altitudes. Mr. Abbott of the Smithsonian Institution, in discussing the diminished transmissibility of the atmosphere during 1903, in the Monthly Weather Review for December, 1903, attributes the loss to the large amount of volcanic dust in the air, and Mr. H. H. Kimball of the Weather Bureau and other investigators agree with him. There were numerous volcanic eruptions in 1902, and the explanation seems reasonable. However, no satisfactory explanation of the possible variation of the solar constant can be given at the present time.

Mr. Kimball has been using a pyrheliometer at Asheville and Black Mountain, N. C., to measure the solar radiation, and later in Washington, and his observations show a small value in insolation in 1903 as compared with 1902, and a similar discovery was made by M. Dufour in his measurements at Lausanne,

Switzerland. Relatively similar results were obtained by the observatory in Warsaw, Russia, and other points in Europe. Dufour calculated that the average radiation through a cloudless sky during January, February and March, 1903, was from 14 to 21 per cent less than the average of these months for the years 1897 to 1902, inclusive. Kimball's observations during certain months in 1903 indicated a falling off in radiation of about 16 per cent as compared with 1902, while Langley concludes that there was a loss in transmissibility in 1903 as compared with 1902 and 1901 of 20 per cent for the green rays, but diminishing for rays of greater wave length, and averaging about 10 per cent for all rays. The temperature during the greater portion of the year 1903 was low over the entire north temperate zone, and a connection between the insolation and the terrestrial temperature has apparently been established. If it develops that there is a secular variation in the quantity of solar radiation received at the outer surface of the Earth's atmosphere, we shall certainly wish to study such variations in connection with the occurrences of sun spots, solar prominences and terrestrial magnetism that are now known to exist, and it will be in order to trace the connection between such variations and seasonal departures from normal weather conditions. The results of the studies in this field of astrophysics seem to justify us in the belief that we may ultimately find some basis for making seasonal long range forecasts. I believe that we are working in the right direction, but progress is certain to be slow, as the immensity of the task is well nigh appalling.—*School Science and Mathematics.*

NOTES ON ANGLE MEASURING INSTRUMENTS.

F. E. HARPHAM.

For Popular Astronomy.

Much observational astronomy is taught today in our high schools and colleges and the student learns in a surprisingly short time that his sight alone gives him very little information in regard to the heavenly bodies. He sees only their apparent positions and size. Should he carefully ascertain these positions, he would notice that those bodies nearest us move in paths which constantly change their directions among the stars. If he observes the Moon near a bright star this evening and looks at it again tomorrow evening he will see that its position has changed with respect to that star. Or if he wishes to note the point of the horizon marked by the setting Sun, he will observe its varia-

tion from a fixed terrestrial reference point.

So much knowledge his eyes will give him and in this respect he is at the beginning—at that point in fact where the science of astronomy must have begun, as we know that as far back as we go in history there was even then a knowledge of the apparent motions of the Sun, Moon and planets. Our student increases his knowledge by following in the footsteps of those old astronomers and as he uses the gnomon and quadrant provided for his first observational work he is interested to know what this simple apparatus accomplished in the hands of men who could think. Many astronomical deductions depend on information furnished by the patient, persistent observations of those men of old who for many centuries had only the gnomon and quadrant to aid them in accumulating knowledge of the motions of the heavenly bodies.

Nearly every important fact in astronomy rests upon the measure of some angle and it can be readily seen that the first observers soon recognized the fact that they must have an angle-measuring instrument. Herodotus ascribes the first one to the Babylonians and gives a description of this instrument, which he calls a gnomon, as consisting merely of a straight staff with a pointed tip.

The altitude of the Sun was perhaps the earliest observation with the gnomon, which was placed in the sunlight where its shadow could be measured at various times during the year. The length of the shadow compared with the height of the gnomon would give the altitude of the Sun. Observation of the varying length of the shadow during the year gave also the highest and lowest points in the Sun's annual path which led to the discovery of the cause of the change of the seasons which we call the obliquity of the ecliptic.

The Egyptians have left a record of an attempt to measure the diameter of the Sun by means of the shadows when the upper and lower edges of the Sun's disc appeared above the horizon on the day of the equinox. But the method was so crude that the result of their measurements gave the diameter of the Sun three times as great as it really is. They succeeded better when they attempted the same measurement by means of the clepsydra, measuring the flow of water during the time of the rising of the Sun's disc and comparing it with the flow for the whole day. They considered that the Sun's diameter was in the same ratio to the entire circumference as the flow of water during the rising of the Sun's disc was to the entire flow for the day.

All the ancient nations claim priority of astronomical knowledge but the first authentic observations seem to be those of the Chinese who record definite observations as early as eleven hundred years before the Christian era. These observations were made with the gnomon in the city of Layang at the times of the Sun's greatest and least altitude. The obliquity of the ecliptic determined from these agrees within one minute with LaPlace's calculated value. Though the compass is not strictly an astronomical instrument, the Chinese claim its invention about 2600 B. C. According to tradition, their king's pursuit of his enemy being hindered by a fog, he constructed a chariot for indicating the south and was thereafter enabled to take advantage of his victories without regard to atmospheric hindrances.

About the year 300 B. C. Timocharis and Aristillus began observations in Greece and for a period of twenty-five years made many careful records of the relative positions of the fixed stars, the places of the planets and times of the solstices. These observations proved most valuable a hundred and fifty years later when Hipparchus made use of them to determine precession.

The first astronomer who attempted to measure the relative distances of the Sun and Moon from the Earth was Aristarchus, another Greek. His method was a very ingenious one and theoretically correct. When the Moon is exactly quartered, as we say, that is, when exactly one-half of her face is illuminated by the Sun, the line joining the center of the Moon and the observer is perpendicular to the line which joins the center of the Moon and Sun. Aristarchus was therefore himself at one angle of a right-angled triangle and by measuring the angular distance between the Moon and Sun, he would have the means of determining the ratio of the distances of those two bodies. Not being in possession of a unit of distance he would not be able to find the distance in miles, but by measuring the angle, which he found to be eighty-seven degrees, he determined the distance of the Sun from the Earth to be about eighteen times greater than the distance of the Moon from the Earth. The exact instant of quartering is difficult to perceive and Aristarchus was in error nearly a minute in his measure of the angle, which made his resulting distance too small. In this observation he probably used the "hemisphere of Bosorus," an instrument consisting of a hollow hemisphere of brass, with degrees marked on its rim.

A few years later Eratosthanes invented the armillary sphere, a series of rings fastened together in such a manner that one ring represented the equator, another the meridian while still a third

ring was not fixed and could be moved to any angle from the meridian. This was a great improvement on all existing instruments and with it Eratosthanes attempted to find the size of the Earth. Knowing in some way that Alexandria, of which city he was librarian, was on the same meridian as the city of Syene in Ethiopia, he selected the day of the summer solstice for his experiment. On that day the gnomon at Syene cast no shadow, showing that the city was situated directly under the tropic and therefore the Sun was overhead at noon. At noon, accordingly, he measured the zenith distance of the Sun at Alexandria and found it to be one-fiftieth of a circumference. Knowing the distance between the two places to be five hundred stadia he found the circumference of the Earth to be five hundred times fifty, or two hundred and fifty thousand stadia, about twenty-four thousand six hundred miles.

The man who really gave astronomy the dignity of a science was Hipparchus a hundred years later. Delambre says that he appears to be the author of every great step in astronomy. He made many observations and invented the well-known astrolabe, an improvement of the armillary sphere. The greater accuracy of his instruments made his observations very valuable both at his own time and in later centuries also. By comparing his own work with that of Timocharis and Aristillus and Aristarchus he found a length of the year in error by only four minutes. He made many investigations of the motions of the Moon and planets and left solar and precession tables of considerable accuracy. He also made a catalogue of over a thousand stars. His work was accurate and his deductions correct. His quadrants and astrolabes were models for many years.

Three hundred years later Ptolemy invented his parallactic rules which he used in measuring the parallax of the Moon. This instrument was composed of three flat pieces of wood, two of them forming the sides of an isosceles triangle while the third formed the base upon which were degree marks. When one side was placed in a vertical position and the other pointed at the Moon, the altitude was read off at once on the third side. Ptolemy also invented a solar quadrant for observations of the Sun, the extreme radii of which represented the horizon and zenith lines.

Some of the gnomons and quadrants of later times were of immense size, the Arabians in the ninth century owning a quadrant of nearly twenty-two feet radius. In the fifteenth century Ulugh Begh had a quadrant nine feet in radius and a gnomon one

hundred and eighty feet in height. He used his quadrant in making the second catalogue of stars, the first catalogue being that of Hipparchus sixteen centuries earlier while with his great gnomon he found the obliquity of the ecliptic to be 23° 30′ 20″, a quite accurate value.

About the time Ulugh Begh was making his catalogue of stars, Columbus was crossing the ocean on his first voyage of discovery, carrying with him the best nautical instrument of that time, a cross-staff. The astrolabe and quadrant were too uncertain at sea for reliable observations and the mariner had to depend upon an instrument which could be held in the hands. The cross-staff was made of two light strips of wood, one about three feet in length and the other twenty-six inches. The shorter piece moved transversely on the longer one. When the altitude of the Sun was to be observed one end of the shorter strip was brought in line with the observer's eye and the center of the Sun while the other end was brought in line with the observer's eye and the horizon. Along the face of the longer strip were marked the degrees of which the shorter strip was the chord as it moved along, and the altitude of the Sun could be read directly. From the altitude of the Sun Columbus could find his latitude.

A hundred years later the quadrants and mural circles of Tycho Brahe were the finest of their kind and with them he made a long series of observations which was the means of leading Kepler to the discovery of the laws of the motions of the planets. Tycho Brahe was an indefatigable observer and his large fortune enabled him to procure the best instruments which the age could produce. By his industry and skill he was admirably qualified to employ them to the best advantage. He discovered that comets move in regions far beyond the Moon and his catalogue of stars compiled from his own observations was by far the most exact published up to that time.

About a hundred years later than Tycho Brahe lived, Hevelius, a rich man of Dantzic whose interest in astronomy led him to become a very skillful observer with the quadrant and circle. Toward the close of his long life devoted to astronomy the telescope was adapted to mural circles but Hevelius continued to use the pinules of Tycho Brahe. This is to be regretted the more as the telescope in the hands of such a practiced observer would have given results of value to later astronomers.

At the time of the application of the telescope to the mural circle Huyghens also applied the pendulum to clock-work and was the first to determine the length of pendulum necessary to mark

a second of time. He was one of the inventors of the micrometer likewise and this system of threads placed in the focus of the telescope greatly facilitated accuracy of observation. Just at this time too, the Danish astronomer Roemer introduced the method of placing the telescope in the meridian attaching it to an axis which would permit motion only in that plane. By using a clock marking sidereal time, the clock time of the star's passage at once gave the star's right ascension, or distance from the vernal equinox. The modern angle-measuring instrument is this transit with a circle attached to the axis for the purpose of measuring also the star's declination, or distance from the equator. This instrument is called a meridian circle and is as nearly perfect as the resource and skill of the modern practical astronomer can make it. The graduations of the circle into degrees and parts of a degree are so fine that they must be read with a microscope, and give the means of extreme precision in the observations, while the star's transit over the threads in the eyepiece is recorded by electricity upon a sheet of paper which can be read later to determine the star's right ascension. Upon this instrument the best efforts of the astronomer have been spent to secure the perfection of detail necessary for most accurate results.

PLANET NOTES FOR APRIL, 1905.

H. C. WILSON.

Mercury may be seen near the western horizon about a half hour after sunset during the first part of April. The planet will be at greatest elongation, east from the Sun 19° 11′, at 8 A. M. April 4, C. S. T. The crescent Moon will be in conjunction with Mercury at 5 A. M. April 6, the planet being then 7° 28′ north of the Moon, as seen from the center of the Earth. Mercury will appear brightest a few days before greatest eastern elongation and will diminish rapidly after that time. The planet will come into inferior conjunction with the Sun April 23, and will be invisible during the remainder of the month.

Venus will be lost in the glare of the Sun soon after the middle of April and will be at inferior conjunction April 27, at 4 A. M. It will be of interest to some of our readers to watch the planet from night to night and see how close to conjunction they can follow it and then to see in the morning how soon they can recover it with the naked eye.

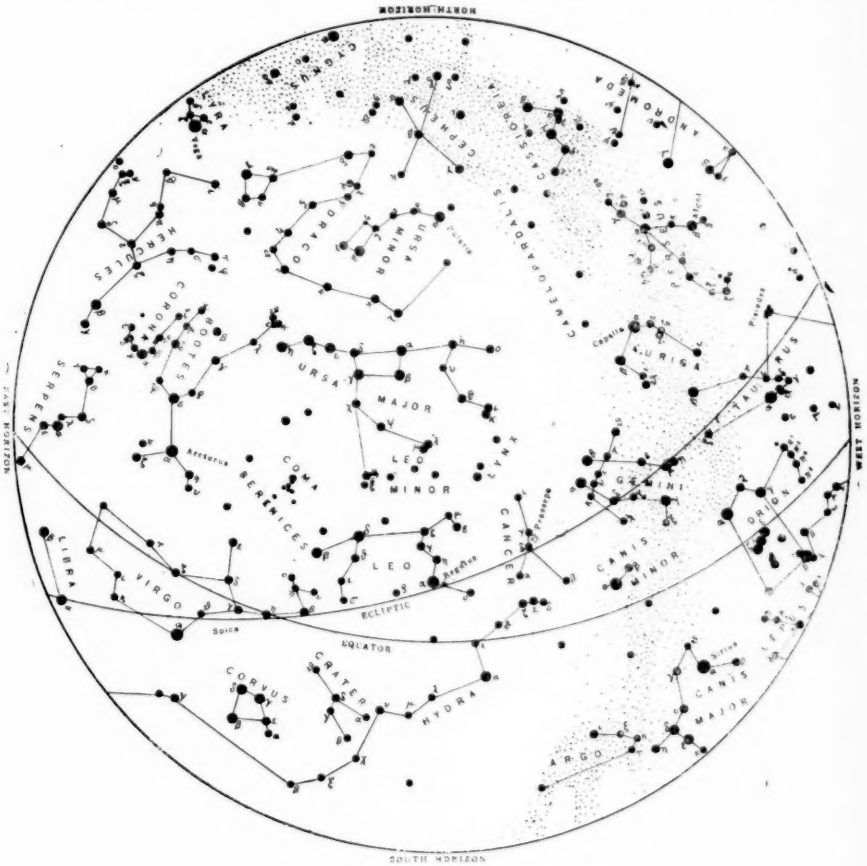
Mars is nearing opposition, which will occur in May, and so can be well seen in the hours after midnight. The planet is to be found in the space between the constellations Scorpio and Libra. It will be stationary in right ascension on the morning of April 2, and after that time will move slowly westward for the remainder of the month. The apparent diameter of the planet will increase from 14″ to 18″ during the month.

Jupiter is nearing the Sun (apparently) and will be at conjunction early in May, so that its position will be quite unfavorable for telescopic observations during April. The two bright planets, Jupiter and Venus, which have been so conspicuous in the evening sky during all this winter, have been gradually near-

ing each other. On April 17, they will be in conjunction in right ascension, Venus being 8° north of Jupiter. Both will then be observed only in the bright twilight soon after sunset.

Saturn may be found toward the southeast an hour before sunrise in the constellation Aquarius, but is not in good position for observation.

Uranus is in Sagittarius, in a bright part of the Milky Way. It is not visible to the naked eye, but may be easily distinguished from the neighboring stars,



THE CONSTELLATIONS AT 9 P. M. APRIL 1, 1905.

with the aid of a telescope of moderate power. The planet will be stationary in right ascension on April 8, and will move slowly westward from that time until September.

Neptune may be found, with the aid of a good telescope, in the early evening, in the constellation Gemini. For its exact position with reference to the faint stars in its vicinity see the chart in our last number p. 96.

Occultations Visible at Washington.

Date. 1905.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N pt.	EMERSION. Washington M. T.	EMERSION. Angle f'm N pt.	Duration.
			h m	°	h m	°	h m
April 8	D.M. + 14°.657	5.9	5 9	149	5 39	191	0 30
8	48 Tauri	6.3	9 38	137	10 12	214	0 34
18	l^2 Virginis	4.8	8 27	102	9 33	309	1 6
20	γ Libræ	4.1	10 42	92	11 49	310	1 7
20	η Libræ	5.5	15 52	132	16 55	253	1 3

Large Sunspot.—During the first two weeks of February a great spot was visible on the Sun. It was so large that it could be seen without a telescope, by using only smoked or tinted glass to protect the eye. At Goodsell Observatory the first photograph of it was taken on February 4 when the spot, or rather group of spots, had already passed the central meridian of the Sun. Measures of the photograph show that the disturbed area of the Sun was between nearly 90,000 miles long and about half as broad. The principal umbra was about 15,000 miles in diameter and very dark. It was in longitude 328° and latitude — 16°. Other spots of the group give longitudes ranging from 324° to 334° and latitudes ranging from — 12° to — 17°. The group was passing around the western limb of the Sun on Feb. 10 and will probably be visible again on the last days of February and the early part of March.

There have been many other smaller spots on the Sun during this month, no less than nine groups of dark spots and eight groups of faculæ being seen at one time. We are evidently now near the maximum of the sunspot period.

Two other notable spots measured on photographs taken Feb. 4 and 5 were in longitude 279°, latitude + 12° and in longitude 264°, latitude — 30°, respectively.

VARIABLE STARS.

105 New Variable Stars in Scorpius.—In the Harvard College Observatory *Circular* No. 90, Professor Pickering gives a list of seventy-two new variable stars, which have been found by Miss Henrietta S. Leavitt in examining photographs of the great nebulous region in the constellations Scorpius and Ophiuchus, and also a list of 33 variables, which have been found in the cluster Messier 4, which is in the same region just a little way west of Antares. All of these stars are faint, very few of them being brighter than the eleventh and none as bright as the tenth magnitude. The range of variation in several cases is quite large.

16 New Variable Stars in Sagittarius.—In the Harvard College Observatory *Circular* No. 91 Professor Pickering gives a list of 16 new variable stars, found by Miss Leavitt in examining photographs of the region about the Trifid Nebula in Sagittarius. A number of these photographs were taken for the study of Phoebe, the Ninth Satellite of Saturn, with the 24-inch Bruce Telescope and were given exposures of from one to three hours. Professor Pickering says: "The total number of new variables discovered by Miss Leavitt and announced in *Circulars* Nos. 78, 79, 82, 86, 90 and 91 is 410."

Variable Star 94. 1901 Cygni—In *A. N.* 3987 Mr. K. Graff of the Hamburg Observatory gives the results of a series of observations which establish the variation of this star and determines the following elements.

Maximum 1904, June 6 = $2416638^d + 275^d$ E.

The range of variation is between 8.7 and 9.3 magnitude. The maxima in 1905 will be about March 8 and December 9.

Variable Star 49.1903 Orionis.—In a letter to the editor of the *Astronomische Nachrichten* dated Jan. 10, 1905, Professor Hartwig says that the variable star 49.1903, discovered by Wolf in the Orion nebula, is now very bright, about 9.10 magnitude and has a period of 268 days. The amplitude of variation is more than five magnitudes.

New Variable Star 188.1904 Draconis.—In *A. N.* 3987 Professor Ceraski of Moscow announces a new variable, probably of the Algol type, discovered by Mme. L. Ceraski on the Moscow photographs. Five plates show the star of the same brightness, about 9.3 magnitude, but on a sixth, taken in 1904 Oct 12, $7^h\ 22^m - 9^h\ 18^m$, Moscow M. T., it is missing and therefore must have been of magnitude 12 or fainter. The following visual observations by M. Blajko are given:

1904	Nov. 30	$7^h.5 - 9^h.4$	Moscow M. T.		9.4^m
	Dec. 2	$9^h\ 8^m$	"	"	10.4
	Dec. 2	9 30	"	"	10.2

The position of the star given by Ceraski is

1855.0	$\alpha =$	18^h	40^m	32^s	$\delta = +62°$	$31'.1$
1900.0		18	40	56	$+62$	33 .8

Mr. Ebel, of Kiel Observatory has found the star in the first volume of the Astrographic Chart Measures of the Vatican Observatory, where it is given as of the 8.5 magnitude on July 29, 1902, $10^h\ 9.7^m$ local mean time. From these measures he determines the place of the star as

1900.0: $\alpha = 18^h\ 40^m\ 48^s.62 \quad \delta = +62°\ 34'\ 32''.2$

New Variable Star 189.1904 Andromedae.—Mr. A. Stanley Williams, in *A. N.* 3987 announces a new variable of long period in Andromeda. The position is approximately

1855: $\alpha = 0^h\ 39.5^m \quad \delta = +31°\ 54'$

On Dec. 7, 1904 the star visually was about 8.3 magnitude. The color is reddish but not very intense. On Oct. 30, 1903 its photographic magnitude was about 10, but on ten other dates from Nov. 10, 1899, to Oct. 7, 1904, the photographs fail to show it, so that in several instances it must have been below the twelfth magnitude.

New Variable Star 190.1904 Cassiopeiæ.—This star is a very near neighbor to the well known variable T Cassiopeiæ, being situated only about 3′ to the east of the latter, and is known as BD. $+54°.49$. Its position for 1855 is

$\alpha = 0^h\ 15^m\ 36^s.0 \quad \delta = +54°\ 59'.6.$

In using this as a comparison star for T Cassiopeiæ, in December 1904, Mr. A. Tass of the O'Gyalla Observatory found a variation of over a magnitude in the brightness of the comparison star. The magnitudes determined with a Zöllner photometer on four dates were as follows: 1904, Dec. 7, 7.23; Dec. 16, 7.75; Dec. 19, 8.47 and Dec. 20, 8.42.

Nomenclature of Newly Discovered Variable Stars.*

Provis. Notation A. N.	Name.	Position for 1900.0 R. A. h	m	s	Decl. °	′	Prec. 1900 R. A. s.	Decl. ′
60.1903	V Piscium	0	17	15	+ 6	7.2	+ 3.08	+ 0.33
156.1904	Z Ceti	1	1	39	— 2	1.0	3.06	0.32
23.1903	RS Sculptoris	1	22	31	— 33	25.6	2.76	0.31
17.1904	RV Andromedae	2	4	34	+ 48	27.6	3.85	0.29
16.1904	RS Persei	2	15	20	+ 56	39.1	4.20	0.28
1.1904	RR Persei	2	21	44	+ 50	49.4	4.02	0.27
155.1904	RT Persei	3	16	44	+ 46	12.2	4.13	0.22
2.1904	RT Tauri	4	58	10	+ 23	30.4	3.63	0.09
11.1904	X Orionis	5	32	36	— 1	49.9	3.03	0.04
20.1904	RU Tauri	5	46.9		+ 15	57	3.45	0.02
157.1904	RS Aurigae	5	56	27	+ 46	16.1	4.47	+ 0 01
133.1904	RR Aurigae	6	4.8		+ 43	11	4.33	— 0.01
12.1904	RTGeminorum	6	40.7		+ 18	44	3.52	0.06
10.1904	RS Monocerotis	7	2	11	+ 5	8.7	3.19	0.09
141.1904	RV Geminorum	7	11	56	+ 24	6.1	3.64	0.10
24.1903	T Canis majoris	7	17	18	— 25	15.6	2.48	0.11
15.1904	RU Geminorum	7	21	0	+ 21	38.4	3.57	0.12
3.1904	Y Cancri	7	58	37	+ 20	24.7	3 50	0 17
183.1904	Z Camelopardalis	8	14	5	+ 73	25.6	6.82	0.18
—	X Ursae majoris	8	33.9		+ 50	29	4.34	0.21
19.1904	S Leonis minoris	9	47	46	+ 35	23.9	3.59	0.28
24.1904	RZ Carinae	10	32.8		— 70	12	1.69	0.31
25.1904	Z Ursae majoris	11	51	17	+ 58	25.7	3.16	0.33
134.1904	Y Ursae majoris	12	35	47	+ 56	23.7	2.76	0.33
113.1904	U Ursae minoris	14	14.9		+ 67	10	1.31	0.28
135.1904	RY Centauri	14	43.3		— 42	5	3.86	0.25
26.1903	Y Normae	16	25	39	— 46	43.7	4.37	0.14
18.1904	RU Ophiuchi	17	28	8	+ 9	29.9	2.85	0.05
136.1904	RV Ophiuchi	17	29	45	+ 7	18.9	2.90	0.04
158.1904	RW Ophiuchi	17	50	30	+ 7	51	2.89	0.01
30.1903	SV Sagittarii	17	57	11	— 24	29.9	3.68	— 0.00
165.1904	V Serpentis	18	11	4	— 15	33.4	3.44	+ 0.02
162.1904	SV Herculis	18	22	18	+ 24	58.0	2.45	0.03
140.1904	V Scuti	18	42	32	— 12	14.4	3.36	0.06
109.1904	ST Lyrae	19	6	39	+ 43	29	1.86	0.10
63.1903	SS Lyrae	19	10	24	+ 46	48.6	1.72	0.10
137.1904	SW Sagittarii	19	13	26	— 31	54.2	3.86	0.11
71.1903	RX Aquilae	19	40	22	+ 8	12.2	2.90	0.14
77.1903	RY Aquilae	19	43	40	+ 11	16.6	2.83	0.15
83.1903	RZ Aquilae	19	49	6	+ 9	24.0	2.88	0.15
161.1904	X Vulpeculae	19	53	19	+ 26	17.3	2.49	0.16
154.1904	WW Cygni	20	0	36	+ 41	18.2	2 06	0.17
5.1904	W Vulpeculae	20	5	53	+ 25	59.4	2.52	0.17
59.1903	WX Cygni	20	14	50	+ 37	8.2	2.23	0.19
4.1904	V Vulpeculae	20	32	17	+ 26	15.4	2.55	0.21
61.1903	VY Cygni	21	0	26	+ 39	34.3	2.29	0.24
138.1904	V Microscopii	21	17.5		— 41	7	3.83	0.25
164.1904	WY Cygni	21	44	43	+ 43	46	2.36	0.28
7.1904	VZ Cygni	21	47	41	+ 42	39.9	2.40	0.28
163.1904	W Lacertae	22	3	11	+ 37	15	2.58	0.29
142.1904	RU Pegasi	22	9	9	+ 12	12.4	2.94	0.30
159.1904	RV Pegasi	22	21	2	+ 29	57.9	2.75	0.30
86.1903	T Tucanae	22	33	58	— 62	4.5	4.00	0.31
110.1904	V Lacertae	22	44	33	+ 55	47.6	2.44	0.32
34.1904	RW Pegasi	22	59.2		+ 14	45	2.98	0.32
108.1904	RS Cassiopeiae	23	32	33	+ 61	52.6	2.77	0.33
160.1904	RT Cassiopeiae	23	41	26	+ 53	57	2.92	0.33
28.1903	Y Ceti	23	54	27	— 24	59.1	+ 3.09	+ 0.33

* From No. 3984 of the *Astronomische Nachrichten.*

Nomenclature of Newly Discovered Variable Stars.—Continued.

Provis. Notation A. N.	Name.	Chart-Place. R. A. h	m	s	Decl. °	′	Magnitude. Max.	Min.	
60.1903	V Piscium	0	14	57	+ 5	52.2	9.5	12	v
156.1904	Z Ceti	0	59	21	− 2	15.5	9	12	v
23.1903	RS Sculptoris	1	21	22	−33	33.4	10	<11	v
17.1904	RV Andromedae	2	1	41	+48	14.7	8½	10½	ph
16.1904	RS Persei	2	12	12	+56	26.6	8	10	ph
1.1904	RR Persei	2	18	43	+50	37.1	9	<13	ph
155.1904	RT Persei	3	13	39	+46	2.3	9.5	11	ph
2.1904	RT Tauri	4	55	27	+23	26.3	9	10	v
11.1904	X Orionis	5	30	19	− 1	51.8	11	<14	ph
20.1904	RU Tauri	5	44.3		+15	56	12	14.5	ph
157.1904	RS Aurigae	5	53	6	+46	15.8	9.2	10.5	ph
133.1904	RR Aurigae	6	1.5		+43	11	?	?	ph
12.1904	RT Geminorum	6	38.1		+18	47	10	<15	ph
10.1904	RS Monocerotis	6	59	47	+ 5	12.7	9	<10.11	v
141 1904	RV Geminorum	7	9	12	+24	10.6	10	<15	ph
24.1903	T Canis majoris	7	16	16	−25	12.9	9	10.5	v
15.1904	RU Geminorum	7	18	19	+21	43.5	12.13	14	v
3.1904	Y Cancri	7	55	59	+20	32.1	12	14	ph
183.1904	Z Camelopardalis	8	8	56	+73	33.8	10	13	ph
—	X Ursae majoris	8	30.7		+50	38	9	<12	ph
19.1904	S Leonis minoris	9	45	4	+35	36.5	8	9	v
24.1904	RZ Carinae	10	32.1		−70	4	9	<13	ph
25.1904	Z Ursae majoris	11	48	56	+58	40.3	?	?	ph
134.1904	Y Ursae majoris	12	33	42	+56	38.6	8	9	ph
113.1904	U Ursae minoris	14	14.0		+67	23	8.5	12	ph
135.1904	RY Centauri	14	41.7		−41	59	?	?	ph
26.1903	Y Normae	16	23	50	−46	40.3	8.8	10	v
18.1904	RU Ophiuchi	17	25	59	+ 9	32.0	9	12	ph
136.1904	RV Ophiuchi	17	27	35	+ 7	20.7	9	12	ph
158.1904	RW Ophiuchi	17	48	20	+ 7	52	10	<12.13	ph
30.1903	SV Sagittarii	17	55	39	−24	29.8	11	14	ph
165.1904	V Serpentis	18	8	29	−15	34.0	9.5	10.5	ph
162.1904	SV Herculis	18	20	27	+24	56.6	9.5	<13	v
140.1904	V Scuti	18	40	0	−12	17.0	12	<14	ph
109.1904	ST Lyrae	19	5	14	+43	25	10	<12	ph
63.1903	SS Lyrae	19	9	8	+46	44.0	9	13	v
137.1904	SW Sagittarii	19	11	49	−31	56.8	9.10	11	ph
71.1903	RX Aquilae	19	38	11	+ 8	5.9	11	<15	ph
77.1903	RY Aquilae	19	41	32	+11	10.0	10	12	ph
83.1903	RZ Aquilae	19	46	57	+ 9	17.2	11	13	ph
161.1904	X Vulpeculae	19	51	27	+26	10.2	9.5	10.5	ph
154.1904	WW Cygni	19	59	3	+41	10.7	9.3	12½	ph
5.1904	W Vulpeculae	20	3	59	+25	51.6	9	10	ph
59.1903	WX Cygni	20	13	10	+36	59.9	?	?	ph
4.1904	V Vulpeculae	20	30	22	+26	6.2	8	10	ph
61.1903	VY Cygni	20	58	43	+39	23.7	9	10	ph
138.1904	V Microscopii	21	15.9		−41	13	?	?	ph
164.1904	WY Cygni	21	42	57	+43	33	8.9	12.13	ph
7.1904	VZ Cygni	21	45	53	+42	27.3	8	9	ph
163.1904	W Lacertae	22	1	15	+37	2	9.10	12.13	ph
142.1904	RU Pegasi	22	6	57	+11	59.1	9.4	11.5	v
159.1904	RV Pegasi	22	18	58	+29	44.3	9	<11	ph
86.1903	T Tuscanae	22	32	18	−62	12.2	8	<14	v
110.1904	V Lacertae	22	42	44	+55	33.4	8.5	9.5	ph
34.1904	RW Pegasi	22	57.0		+14	31	9	12	ph
108.1904	RS Cassiopeiae	23	30	29	+61	37.7	9	11	ph
160.1904	RT Cassiopeiae	23	39	15	+53	42	10	<12	ph
28.1903	Y Ceti	23	53	10	−25	7.5	9.8	<11.5	ph

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc.

U Cephei.

	d	h
Apr.	3	11
	5	23
	8	11
	10	23
	13	11
	15	22
	18	10
	20	22
	23	10
	25	22
	28	9
	30	21

Z Persei.

Apr.	2	22
	5	23
	9	0
	12	2
	15	3
	18	5
	21	6
	24	7
	27	9
	30	10

Algol.

Apr.	3	17
	6	14
	9	11
	12	8
	15	5
	18	1
	20	22
	23	19
	26	16
	29	13

RT Persei.

Apr.	1	11
	2	7
	3	4
	4	0
	4	21
	5	17
	6	13
	7	10
	8	6
	9	2
	9	23
	10	19
	11	16
	12	12
	13	8
	14	5
	15	1
	15	22

RT Persei.

	d	h
Apr.	16	18
	17	14
	18	11
	19	7
	20	3
	21	0
	21	20
	22	17
	23	13
	24	9
	25	6
	26	2
	26	23
	27	19
	28	15
	29	12
	30	8

λ Tauri.

Apr.	1	4
	5	3
	9	2
	13	1
	16	23
	20	22
	24	21
	28	20

R Canis Maj.

Apr.	1	1
	2	4
	3	8
	4	11
	5	14
	6	18
	7	21
	9	0
	10	3
	11	7
	12	10
	13	13
	14	16
	15	20
	16	23
	18	2
	19	5
	20	9
	21	12
	22	15
	23	18
	24	22
	26	1
	27	4
	28	8
	29	11
	30	14

Y Camelopard.

	d	h
Apr.	1	18
	5	2
	8	9
	11	16
	15	0
	18	7
	21	14
	24	22
	28	6

RR Puppis.

Apr.	2	0
	8	10
	14	21
	21	7
	27	17

V Puppis.

Apr.	2	5
	3	16
	5	3
	6	14
	8	1
	9	12
	10	22
	12	9
	13	20
	15	7
	16	18
	18	5
	19	16
	21	3
	22	14
	24	1
	25	12
	26	22
	28	9
	29	20

S Cancri.

Apr.	8	5
	17	17
	27	4

S Antliæ.

Apr.	1	16
	2	16
	3	15
	4	14
	5	14
	6	13
	7	12
	8	12
	9	11
	10	10
	11	10
	12	9
	13	8

S Antliæ.

	d	h
Apr.	14	8
	15	7
	16	6
	17	6
	18	5
	19	4
	20	4
	21	3
	22	2
	23	2
	24	1
	25	1
	26	0
	26	23
	27	23
	28	22
	29	21
	30	21

S Velorum.

Apr.	1	17
	7	15
	13	13
	19	12
	25	10

W. Urs. Maj.

Apr. 1-30 14^h

RR Velorum.

Apr.	1	3
	3	0
	4	20
	6	17
	8	13
	10	10
	12	6
	14	3
	15	23
	17	20
	19	16
	21	13
	23	9
	25	6
	27	2
	28	23
	30	19

Z Draconis.

Apr.	1	14
	2	22
	4	7
	5	15
	7	0
	8	8
	9	17

Z Draconis.

	d	h
Apr.	11	2
	12	10
	13	19
	15	3
	16	12
	17	21
	19	5
	20	14
	21	22
	23	7
	24	15
	26	0
	27	9
	28	17
	30	2

δ Libræ.

Apr.	2	13
	4	21
	7	5
	9	13
	11	21
	14	5
	16	12
	18	20
	21	4
	23	12
	25	20
	28	4
	30	12

U Coronæ.

Apr.	1	20
	5	6
	8	17
	12	4
	15	15
	19	2
	22	14
	26	1
	29	11

R Aræ.

Apr.	5	9
	9	19
	14	6
	18	16
	23	2
	27	12

U Ophiuchi

Apr.	1	7
	2	3
	2	23
	3	19
	4	15
	5	11

Minima of Variable Stars of the Algol Type.—Continued.

U Ophiuchi.

	d	h
Apr.	6	7
	7	4
	8	0
	8	20
	9	16
	10	12
	11	8
	12	4
	13	0
	13	21
	14	17
	15	13
	16	9
	17	5
	18	1
	18	21
	19	17
	20	14
	21	10
	22	6
	23	2
	23	22
	24	18
	25	14
	26	10
	27	7
	28	3
	28	23
	29	19
	30	15

Z Herculis.

Apr.	1	6
	3	9
	5	6
	7	9
	9	6
	11	9
	13	6
	15	8
	17	5
	19	8
	21	5
	23	8
	25	5
	27	8
	29	5

RS Sagittarii.

	d	h
Apr.	2	18
	5	3
	7	13
	9	23
	12	9
	14	19
	17	5
	19	15
	22	1
	24	11
	26	21
	29	7

V Serpentis.

Apr.	1	6
	4	17
	8	4
	11	15
	15	2
	18	13
	22	0
	25	11
	28	21

RX Herculis.

Apr.	1	8
	2	5
	3	3
	4	0
	4	21
	5	19
	6	16
	7	13
	8	11
	9	8
	10	5
	11	3
	12	0
	12	21
	13	19
	14	16
	15	14
	16	11
	17	8
	18	6
	19	3

RX Herculis.

	d	h
Apr.	20	0
	20	22
	21	19
	22	16
	23	14
	24	11
	25	8
	26	6
	27	3
	28	0
	28	22
	29	19
	30	16

RV Lyræ.

Apr.	3	9
	7	0
	10	14
	14	4
	17	19
	21	9
	25	0
	28	14

U Sagittæ.

Apr.	1	18
	5	3
	8	12
	11	21
	15	6
	18	16
	22	1
	25	10
	28	19

SY Cygni.

Apr.	3	2
	9	2
	15	2
	21	2
	27	2

WW Cygni.

Apr.	2	5
	5	12

WW Cygni.

	d	h
Apr.	8	20
	12	4
	15	11
	18	19
	22	2
	25	10
	28	18

SW Cygni.

Apr.	4	21
	9	11
	14	1
	18	14
	23	4
	27	18

VW Cygni.

Apr.	2	21
	11	8
	19	18
	28	4

UW Cygni.

Apr.	3	20
	7	6
	10	17
	14	4
	17	15
	21	2
	24	13
	27	23

W Delphini.

Apr.	2	16
	7	11
	12	6
	17	2
	21	21
	25	16
	30	12

Y Cygni.

Apr.	2	7
	3	17

Y Cygni.

	d	h
Apr.	5	7
	6	17
	8	7
	9	17
	11	7
	12	17
	14	7
	15	17
	17	7
	18	17
	20	7
	21	17
	23	7
	24	17
	26	7
	27	17
	29	7
	30	16

VV Cygni.

Apr.	2	6
	3	17
	5	5
	6	16
	8	4
	9	15
	11	2
	12	14
	14	1
	15	13
	17	0
	18	12
	19	23
	21	11
	22	22
	24	9
	25	21
	27	8
	28	20
	30	7

UZ Cygni.

Apr.	28	13

Maxima of RZ Lyræ.

Period $12^h\ 16^m\ 15^s.0$.

	d	h
Apr.	1	9
	2	9
	3	10
	4	11
	5	11
	6	12
	7	12
	8	13

	d	h
Apr.	9	13
	10	14
	11	15
	12	15
	13	16
	14	16
	15	17
	16	17

	d	h
Apr.	17	18
	18	18
	19	19
	20	19
	21	20
	22	21
	23	21
	24	22

	d	h
Apr.	25	22
	26	23
	27	23
	29	0
	30	0

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
S Triang. Austr.	Apr. 1	5	Apr. 3	7	S Triang. Austr.	Apr. 13	21	Apr. 15	23
T Velorum	1	9	2	18	TX Cygni	14	2	19	5
δ Cephei	1	13	10	22	VY Cygni	14	4	16	6
S Muscae	1	20	5	7	Y Sagittarii	14	23	17	1
T Crucis	2	4	4	5	SU Cygni	15	5	16	13
X Sagittarii	2	7	5	4	U Vulpeculae	15	6	17	9
S Crucis	2	22	4	10	ζ Geminorum	15	6	20	6
U Aquilae	3	3	5	7	T Velorum	15	7	16	16
Y Sagittarii	3	10	5	12	X Cygni	15	13	20	16
V Carinæ	3	10	5	14	T Crucis	15	15	17	16
V Velorum	3	12	4	11	κ Pavonis	16	3	20	12
SU Cygni	3	16	5	0	X Sagittarii	16	7	19	4
Y Ophiuchi	4	5	10	10	RV Scorpii	16	9	17	18
RV Scorpii	4	7	5	16	V Centauri	16	10	17	21
T Vulpeculae	4	10	5	19	S Sagittae	16	11	19	21
β Lyrae	4	13	7	15	V Velorum	16	15	17	14
ζ Geminorum	5	3	10	3	R Triang. Austr.	16	16	17	16
W Geminorum	5	6	7	21	V Carinæ	16	19	18	23
V Centauri	5	10	6	21	S Crucis	17	0	18	12
T Velorum	6	0	7	9	U Aquilae	17	4	19	8
W Sagittarii	6	1	9	1	β Lyræ	17	11	20	13
U Sagittarii	6	3	9	2	δ Cephei	17	15	19	0
R Crucis	6	9	7	18	T Vulpeculae	17	18	19	3
η Aquilae	6	3	8	12	R Crucis	18	1	19	10
VY Cygni	6	8	8	10	SU Cygni	19	2	20	10
R Triang. Austr.	6	13	7	13	U Sagittarii	19	15	22	14
δ Cephei	6	22	8	7	T Velorum	19	22	21	7
κ Pavonis	7	1	11	10	S Normae	20	1	24	10
U Vulpeculae	7	7	9	10	R Triang. Austr.	20	2	21	2
SU Cygni	7	12	8	20	S Triang. Austr.	20	5	22	7
S Triang. Austr.	7	13	9	15	η Aquilae	20	11	22	20
S Crucis	7	14	9	2	Y Sagittarii	20	18	22	20
V Velorum	7	21	8	20	W Geminorum	20	18	23	9
S Sagittae	8	2	11	12	V Velorum	21	0	21	23
T Vulpeculae	8	21	10	6	S Muscae	21	3	24	14
T Crucis	8	22	10	23	W Sagittarii	21	5	24	5
Y Sagittarii	9	5	11	7	Y Ophiuchi	21	8	27	13
X Sagittarii	9	7	12	4	T Crucis	21	10	23	11
R Triang. Austr.	9	22	10	22	S Crucis	21	17	23	5
T Monocerotis	10	0	17	22	V Centauri	21	22	23	9
U Aquilae	10	3	12	7	VY Cygni	22	2	24	4
V Carinae	10	3	12	7	RV Scorpii	22	11	23	20
S Normae	10	7	14	16	SU Cygni	22	22	24	6
RV Scorpii	10	8	11	17	δ Cephei	23	0	24	9
T Velorum	10	15	12	0	U Vulpeculae	23	6	25	9
V Centauri	10	22	12	9	X Sagittarii	23	7	26	4
β Lyræ	11	0	14	7	R Triang. Austr.	23	11	24	11
SU Cygni	11	9	12	17	V Carinæ	23	12	25	16
S Muscae	11	12	14	23	R Crucis	23	21	25	6
R Crucis	12	5	13	14	β Lyrae	23	22	27	5
V Velorum	12	6	13	5	U Aquilae	24	4	26	8
δ Cephei	12	6	13	15	T Velorum	24	14	25	23
S Crucis	12	7	13	19	S Sagittae	24	20	28	6
W Virginis	12	18	20	22	κ Pavonis	25	6	29	15
U Sagittarii	12	21	15	20	V Velorum	25	9	26	8
W Geminorum	13	0	15	15	ξ Geminorum	25	10	30	10
T Vulpeculae	13	7	14	16	U Sagittarii	26	9	29	8
R Triang. Austr.	13	7	14	7	S Crucis	26	9	27	21
η Aquilae	13	7	15	16	Y Sagittarii	26	12	28	14
W Sagittarii	13	15	16	15	S Triang. Austr.	26	12	28	14

Variable Stars of Short Period not of the Algol Type.—(Continued.)

	Maximum.		Minimum.			Maximum.		Minimum.	
	d	h	d	h		d	h	d	
T Vulpeculae	Apr. 26	14	Apr. 27	23	T Velorum	Apr. 29	5	Apr. 30	14
SU Cygni	26	18	28	2	R Crucis	29	16	32	1
R Triang. Austr.	26	21	27	21	V Velorum	29	18	30	17
V Centauri	27	10	28	21	S Normae	29	19	34	4
η Aquilae	27	16	30	1	W Virginis	30	0	38	4
δ Cephei	28	9	29	18	T Crucis	30	3	32	4
RV Scorpii	28	12	29	21	V Carinae	30	4	32	8
W Geminorum	28	12	31	3	R Triang. Austr.	30	6	31	6
W Sagittarii	28	20	31	20	X Sagittarii	30	8	33	5
TX Cygni	29	20	33	23	β Lyræ	30	9	33	11

Approximate Magnitudes of Variable Stars Feb. 10, 1905.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.	Name.	R. A. 1900.		Decl. 1900.		Magn.
	h	m	°	′			h	m	°	′	
T Androm.	0	17.2	+26	26	9.4*d*	R Camelop.	14	25.1	+84	17	9.4 *i*
T Cassiop.	0	17.8	+55	14	8.3 *i*	R Bootis	14	32.8	+27	10	10.0*d*
R Androm.	0	18.8	+38	1	9.1 *i*	S Librae	15	15.6	−20	2	*u*
S Ceti	0	19.0	− 9	53	*f*	S Serpentis	15	17.0	+14	40	*f*
S Cassiop.	1	12.3	+72	5	8.3 *i*	S Coronae	15	17.3	+31	44	8.8 *i*
R Piscium	1	25.5	+ 2	22	12.6*d*	S Urs. Min.	15	33.4	+78	58	8.8*d*
U Persei	1	52.9	+54	20	10.3*d*	R Coronae	15	44.4	+28	28	6.0
R Arietis	2	10.4	+24	36	10.3*d*	V "	15	45.9	+39	52	9.5 *i*
o Ceti	2	14.3	− 3	26	3.7	R Serpentis	15	46.1	+15	26	*f*
S Persei	2	15.7	+58	8	9.0 *i*	R Herculis	16	1.7	+18	38	13 *f*
R Ceti	2	20.9	− 0	38	*f*	R Scorpii	16	11.7	−22	42	*u*
U "	2	28.9	−13	35	9.0*d*	S "	16	11.7	−22	39	*u*
R Trianguli	2	31.0	+33	50	11.5	U Herculis	16	21.4	+19	7	10.8 *i*
R Persei	3	23.7	+35	20	13 *f*	W Herculis	16	31.7	+37	32	12 *d*
R Tauri	4	22.8	+ 9	56	10.3*d*	R Draconis	16	32.4	+66	58	11.7*d*
S "	4	23.7	+ 9	44	13.0 *i*	S Herculis	16	47.4	+15	7	12.5*d*
R Aurigæ	5	9.2	+53	28	8.8 *i*	R Ophiuchi	17	2.0	−15	58	*s*
U Orionis	5	49.9	+20	10	10.0 *i*	T Herculis	18	5.3	+31	0	11 *i*
R Lyncis	6	53.0	+55	28	11.0*d*	R Scuti	18	42.2	− 5	49	*s*
R Gemin.	7	1.3	+22	52	12.5*d*	R Aquilae	19	1.6	+ 8	5	*u*
S Canis Min.	7	27.3	+ 8	32	8.3*d*	R Sagittarii	19	10.8	−19	29	*s*
R Cancri	8	11.0	+12	2	10.5*d*	S "	19	13.6	−19	12	*s*
V "	8	16.0	+17	36	8 8	R Cygni	19	34.1	+49	58	8.1*d*
S Hydrae	8	48.4	+ 3	27	12 *d*	RT "	19	40.8	+48	32	12 *d*
T "	8	50.8	− 8	46	10.0*d*	X "	19	46.7	+32	40	6.8*d*
R Leo. Min.	9	39.6	+34	58	10.2*d*	S "	20	3.4	+57	42	*f*
R Leonis	9	42.2	+11	54	9.0 *i*	RS "	20	9.8	+38	28	7.2
R Urs. Maj.	10	37.6	+69	18	*f*	R Delphini	20	10.1	+ 8	47	*u*
R Comae Ber.	11	59.1	+19	20	13.2*d*	U Cygni	20	16.5	+47	35	11 *d*
T Virginis	12	9.5	− 5	29	11 *d*	V "	20	38.1	+47	47	*f*
R Corvi	12	14.4	−18	42	9.5*d*	T Aquarii	20	44.7	− 5	31	*s*
Y Virginis	12	28.7	− 3	52	*f*	R Vulpec.	20	59.9	+23	26	8
T Urs. Maj.	12	31.8	+60	2	8 *i*	T Cephei	21	8.2	+68	5	7.0 *i*
R Virginis	12	33.4	+ 7	32	11 *d*	S "	21	36.5	+78	10	9.8 *i*
S Urs. Maj.	12	39.6	+61	38	7.7	S Lacertae	22	24.6	+39	48	8.3 *i*
U Virginis	12	46.0	+ 6	6	9.5*d*	R "	22	38.8	+41	51	*f*
V "	13	22.6	− 2	39	*f*	S Aquarii	22	51.8	−20	53	*s*
R Hydrae	13	24.2	−22	46	6.3 *i*	R Pegasi	23	1.6	+10	0	12 *f*
S Virginis	13	27.8	− 6	41	10.6*d*	S "	23	15.5	+ 8	22	10.0*d*
R Can. Ven.	13	44.6	+40	2	*f*	R Aquarii	23	38.6	+15	50	6.5 *i*
S Bootis	14	19.5	+54	16	*f*	R Cassiop.	23	53.3	+50	50	12 *i*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that the light is increasing; *d*, that the light is decreasing; *s*, that it is near the Sun; and *u*, that its magnitude is unknown.

From observations made at the Vassar, Mt. Holyoke and Harvard Observatories.

Maxima of UY Cygni.

Period $13^h\ 27^m\ 27^s.59$. The minimum occurs $1^h\ 55^m$ before the maximum.

	d	h		d	h		d	h		d	h
Apr.	1	18	Apr.	9	14	Apr.	17	10	Apr.	25	7
	2	21		10	17		18	13		26	10
	3	23		11	20		19	16		27	13
	5	2		12	23		20	19		28	16
	6	5		14	2		21	22		29	19
	7	8		15	5		23	1		30	21
	8	11		16	8		24	4			

Maxima of Y Lyræ.

Period $12^h\ 03^m.9$. The minimum occurs $1^h\ 40^m$ before the maximum.

	d	h		d	h		d	h		d	h
Apr.	1- 3	1	Apr.	4-11	2	Apr.	12-19	3	Apr.	20-26	4
	27-30	5									

COMET AND ASTEROID NOTES.

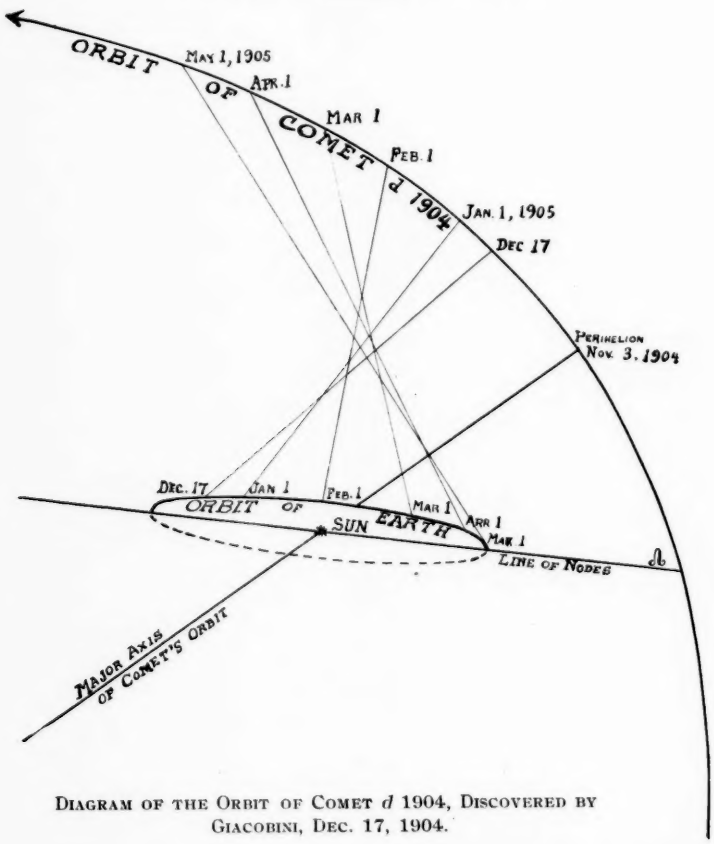


DIAGRAM OF THE ORBIT OF COMET *d* 1904, DISCOVERED BY GIACOBINI, DEC. 17, 1904.

Comet *d* 1904.—This comet is growing faint very rapidly and is now a very difficult object. The accompanying diagram shows the relation of the comet's orbit to that of the Earth. It it inclined more than 90° to the plane of the ecliptic. In the diagram the plane of the paper is made the plane of the comet's orbit, and the Earth's orbit is so projected that the reader is looking at its plane from below instead of from above. The dotted part of the Earth's orbit should appear to be on the farther side of the plane of the comet's path. The orbit appears to be a parabola. Several sets of elements are at hand, the latest being by Mr. Morgan and Miss Lamson of the U. S. Naval Observatory.

Elements of Comet *d* 1904.—The following elements were computed by R. G. Aitken of Lick Observatory from observations on Dec. 19 and 27, 1904, and Jan. 9, 1905.

ELEMENTS OF COMET *d* 1904.

$T = 1904$ Nov. 3.2272 Gr. M. T.
$\omega = 40°\ 42'\ 34.''8$
$\Omega = 218\ \ 28\ \ 04.\ \ 5$ } 1905.0
$i = \ 99\ \ 36\ \ 41.\ \ 2$
$\log q = 0.274540.$

Residuals for the middle place: $\Delta\lambda'$ as $\beta = +3.''3$; $\Delta\beta' = -3.''8$

EPHEMERIS OF COMET *d* 1904 (GIACOBINI).
From Lick Observatory Bulletin No. 69.
(For Greenwich Mean Midnight.)

1905.	True α h	m	s	True δ °	′	log *r*	log Δ	Br.
March 6.5	21	29	40	+62	33.1	0.3824	0.4067	0.56
8.5		40	07	62	54.8			
10.5	21	50	31	63	14.4	0.3877	0.4159	0.52
12.5	22	00	50		32.1			
14.5		11	02	63	47.9	0.3930	0.4253	0.49
16.5		21	07	64	01.9			
18.5		31	04		14.3	0.3983	0.4347	0.46
20.5		40	52		25.1			
22.5		50	30		34.4	0.4037	0.4442	0.43
24.5	22	59	57		42.5			
26.5	23	09	13		49.3	0.4090	0.4536	0.40
28.5		18	18		55.0			
30.5		27	11	64	59.7	0.4143	0.4629	0.37
April 1.5		35	52	65	03.5			
3.5	23	44	21	+65	06.5	0.4196	0.4720	0.34

Brightness December 20, 1904 = 1.0.

R. G. AITKEN.

ELEMENTS AND EPHEMERIS OF COMET *d* 1904 (Giacobini.)

By Herbert R. Morgan and Eleanor A. Lamson.

[Communicated by Rear-Admiral Colby M. Chester, U. S. N. Superintendent.]

The following elements were deduced from observations made at Nice, Dec. 18; Lick, Dec. 19; Washington, Dec. 20 and Dec. 21; at Washington, Dec. 28 and Jan. 1; and at Washington Jan 14.

ELEMENTS.

$T = $ Nov. 2.37708 G. M. T. 1904.
$\omega = 40°\ 11'\ 29''$
$\Omega = 218\ \ 21\ \ 4$ } Mean Eq. 1905.0
$i = \ 99\ \ 34\ \ 30$
$q = 1.87676$

Residuals (O — C): $\cos\beta\Delta\lambda = +7''$, $\Delta\beta = -8''$.

CONSTANTS TO THE EQUATOR.

$x = r\,[9.898168]\sin(302^\circ\ 41'\ 38'' + v)$
$y = r\,[9.800168]\sin(284\ \ 35\ \ 20\ + v)$
$z = r\,[9.994709]\sin(\ 25\ \ 42\ \ 58\ + v)$

EPHEMERIS.

G. M. T. 1905.	α h m s	δ ° ′	Light.
Feb. 17.5	20 0 56	+57 56.2	0.72
21.5	20 21 13	59 16.5	0.67
25.5	20 41 53	60 27.3	0.64
Mar. 1.5	21 2 47	61 28.7	0.61
5.5	21 23 44	62 21.0	0.57
9.5	21 44 34	63 4.8	0.53
13.5	22 5 7	63 40 5	0.49
17.5	22 25 13	64 9.1	0.46
21.5	22 44 44	64 31.2	0.43
25.5	23 3 36	64 47.8	0.40
Mar. 29.5	23 21 44	64 59.8	0.37
Apr. 2.5	23 39 4	+65 7.9	0.35

Brightness Dec. 20, unity.

Corr. to ephemeris Feb. 2.9, $\Delta\alpha = +16^s$, $\Delta\delta = +0.'6$.

Comet *e* 1904.—This comet is also growing fainter but may still be seen with a small telescope. The orbit appears to be elliptic but the period is yet quite uncertain. The diagram (frontispiece) was prepared from elements computed by Aitken of Lick Observatory, and communicated by telegram to Harvard College Observatory. The elements depend upon observations made Dec. 31, 1904, Jan. 17 and 27, 1905, and agree fairly well with similar elements computed by Fayet at the Observatory of Paris.

ELLIPTIC ELEMENTS OF COMET *e* 1904 (BORRELLY).

From Lick Observatory Bulletin No. 69.

Epoch = 1905 January 0.0
$M = -2^\circ\ 13'\ 51''.7$
$\omega = 352\ \ 08\ \ 34\ .0$
$\Omega = \ 76\ \ 35\ \ 10\ .1$
$i = \ 30\ \ 35\ \ 48\ .6$

$\phi = 38^\circ\ \ 55'\ \ 00''.0$
$\log a = 0.575636$
$\log e = 9.798092$
$\mu = 485.''9067$

CONSTANTS FOR THE EQUATOR 1905.0.

$x = r\,[9.938934]\sin(156^\circ\ 39'\ 23''.6 + v)$
$y = r\,[9.950647]\sin(\ 83\ \ 23\ \ 11\ .9 + v)$
$z = r\,[9.825848]\sin(\ 27\ .\ 27\ \ 32\ .2 + v)$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1905	True α h m s	True δ ° ′ ″	log *r*	log Δ	Br.
February 11.5	2 34 39.8	+22 29 45	0.1556	0.0810	0.46
13.5	39 31.8	23 40 46			
15.5	44 29.7	24 49 55	0.1587	0.0935	0.43
17.5	49 33.7	25 57 12			
19.5	2 54 43.9	27 02 36	0.1622	0.1061	0.40
21.5	3 00 00.3	28 06 08			
23.5	05 22.8	29 07 46	0.1660	0.1187	0.37
25.5	10 51.4	30 07 29			
27.5	16 26.1	31 05 17	0.1701	0.1314	0.34
March 1.5	22 07.0	32 01 10			
3.5	27 54.0	32 55 08	0.1745	0.1440	0.31
5.5	33 47.1	33 47 11			
7.5	39 46.1	34 37 18	0.1792	0.1567	0.29
9.5	3 45 51.0	+35 25 30			

		True α h	m	s	True δ °	′	″	log *r*	log Δ	Br.
March	11.5	3	52	01.7	+36	11	46	0.1842	0.1692	0.27
	13.5	3	58	18.1	36	56	06			
	15.5	4	04	39.9	37	38	30	0.1894	0.1817	0.25
	17.5		11	06.9	38	18	58			
	19.5		17	39.0	38	57	31	0.1948	0.1940	0.23
	21.5		24	16.0	39	34	08			
	23.5		30	57.7	40	08	49	0.2004	0.2063	0.21
	25.5		37	43.8	40	41	35			
	27.5		44	34.0	41	12	26	0.2061	0.2184	0.19
	29.5		51	28.0	41	41	23			
March	31.5	4	58	25.9	+42	08	25	0.2119	0.2303	0.18

Brightness December 31, 1904=1.0.

R. G. AITKEN.

New Asteroids.—The following have been added to the list of new minor planets since our last note:

	Discovered by	at	Local Mean Time.	h	m	R. A. h	m	Decl. °	′	Mag.
1904 PN	Wolf	Heidelberg	1904 Dec. 14	12	07	5	11.2	+24	07	13.2
PO	Wolf	"	14	12	07	4	55 8	+24	43	12.5
PP	Wolf	"	27	7	38	4	55.7	+25	1	13.0
1905 PQ	Wolf	"	1905 Jan. 1	6	39	5	35.4	+23	17	13.2
PR	Wolf	"	1	6	39	5	53.1	+23	01	12.8.
PS	Götz	"	8	12	58	8	33.0	+18	37	10.0
PT	Wolf	"	14	17	28	8	59.2	+16	43	13.0
PU	Götz	"	14	14	45	8	30.9	+	4 36	9.6
PV	Wolf	"	22	6	27	1	30.5	+	8 26	13.5

GENERAL NOTES.

Monsieur Maurice Farman, Observatoire de Chevreuse à Jagny, par Dampierre, (Seine-et-Oise) France very much wishes to receive all memoirs of other publications containing double star measures. He will pay the postage on each volume.

Radiant of Perseid Shower.—Referring to a note in the February number of POPULAR ASTRONOMY, page 107, entitled, "Meteoric Observations" Mr. Denning, of Bristol, England, in speaking of the August meteors refers to a note from me in the same Journal, page 500, in which I suggested that the radiant must have shifted to the westward. This was certainly the grandest and most impressive meteoric display ever witnessed by the writer. It was not easy in the early evening to locate the radiant, owing to low altitude, but as the constellations swung from the north-east to the zenith, an approximation could easily be determined. In making mention of the place given by Mr. Denning, I referred to the table, page 216, of D. P. Todd's fascinating work, "Stars and Telescopes," which gives R. A. 3^h Decl. 57° +, nearly the same as he finds the radiant on August 11. In my approximation of the radiant I used only the eye, consequently could not arrive at the exactness of Mr. Denning, but the meteors being of such splendor it was indeed easy to follow backward their paths to intersection, and from those retraced with the assistance of Mrs. Wetherbee, the radiant was found approximately, R. A. $2^h\ 20^m$, Decl. 54° +, which is somewhat west of the point of radiation as seen by Mr. Denning. This discrepancy I am unable to account for.

Meteoric Astronomy is a fascinating study and one to which I have given much attention of late years. I often with much pleasure read Mr. Denning's articles in POPULAR ASTRONOMY, which are of so much importance to the amateur

worker, and always esteem it a great privilege to find the work of his pen whom the world acknowledges the greatest living authority on Meteoric Astronomy.

ALBION, N. Y., Feb. 6, 1905. WESTON WETHERBEE.

Sun-Spot Observations 1904.

Month.	No. of Obs.	N. of Equator. No. Groups.	Av. Lat.	S. of Equator. No. Groups.	Av. Lat.	Av. No. at each Obs.	New Groups.
January	10	3	+17°.5	3	−21.5	1.5	6
February	18	4	16 .1	2	18.5	1.2	6
March	18	7	12 .0	5	20.6	2.4	12
April	12	4	10 .3	5	17.6	3.2	9
May	20	12	10 .2	10	21.4	3.1	18
June	16	7	12 .3	4	21.7	3.1	10
July	13	5	.....	2	.....	1.6	7
August	12	6	.....	7	.....	3.1	13
September	14	6	20 .2	1	25.2	1.4	7
October	16	11	12 .5	8	18.7	3.5	18
November	19	9	15 .8	8	18.8	3.0	14
December	10	11	+12 .7	3	−23 0	3.9	9
Total	178	85		58			129

Average number at each observation.....2.59
Average latitude of spots north of equator.....+ 14°.0
Average latitude of spots south of equator.....— 20°.7

Only eight observations were made when no spots were visible. These were upon Jan. 28 and 30, Feb. 2, 16, 17, Sept. 3, 7, 9.

Observations were usually made by projecting the image of the Sun upon a screen attached to the eight-inch equatorial telescope, approximate latitudes being obtained from Thomson's Disks. Twenty-nine of these observations, from July 1st to Sept. 10th, were made at Chicago, with an inch and one-half glass. Latitudes for these dates were not recorded.

ANNE SEWELL YOUNG.

MOUNT HOLYOKE COLLEGE OBSERVATORY.

The February Sun-Spots.— Under the head of celestial phenomena, elsewhere in this number, will be found some notes about the great spot on the Sun which was so plainly visible during the first days of last month. We have also given, in this issue, a brief article descriptive of the appearance of this group of sun-spots, mentioning some interesting details about it that could only be known to those favored with a telescope who would give the matter study for days consecutively.

During the time of greatest activity that came under our notice at Goodsell Observatory, very many visitors from the citizens and the colleges at Northfield came to the observatory to see, by the aid of the telescope, for themselves, what had claimed so much attention in the daily papers for some time previously.

The very common questions repeatedly asked were:—What is a sun-spot? What causes it? How long will it be visible?

We have space only to say a little more about these very interesting and very important solar phenomena. The sun-spot is generally considered to be an irregular, black hollow formed in the solar surface by a collection of cooler gases that overload its surface at that place and thereby cause a sink in it, or, if there is less pressure from beneath the surface than the ordinary amount, from any cause, the sinking of a portion of it may be caused by its own weight. Surrounding this black patch is a dark cape that is brighter on its inner surface and less so on its outer. Near the outer edge of this penumbral cape and in its vicinity on all sides are pores through which immense volumes of gases are pour-

ing out from the interior of the Sun. This condition causes great activity to be apparent usually on all sides of the spot or group of spots which appears to be the center of the so-called solar storm that is in progress. This plainly gives what may be called a kind of vertical circulation of the solar masses in the region under consideration, an uprush of the highly heated vapors in and near the outer border of the penumbra, and a downrush of the cooler vapors that descend through the dark hollow of the spot called its umbra. The depth of sun-spots below the general level is very hard to determine. Astronomers think it may vary in different spots from 500 to 2,000 miles. The sizes of different spots vary greatly, and the dimensions of the same spot are not usually the same from day to day. This was notably the case in the great group during the first days of last month. What has been said about uncertainty of the depth and size of the sun-spot is equally true of its life, or time of existence. It may last a few days or it may exist for more than a whole year. One sun-spot has been known to live for eighteen months. We shall probably have more information soon about the great spot of February last.

The Science Year Book for 1905.—We are just in receipt of the *Science* Year Book for the year 1905. It was quite late in reaching us, hence the late notice of it. It is the finest volume of the annual series we have seen. We have made daily use of this splendid scientific diary for four years past, and we still deem it worth many times its cost, which is five shillings. The first 165 pages of the book contains a brief review of the present condition of Science and Astronomy in particular with very complete tables of data by professional men whose names assure the reader of the accuracy and value of the information they contain. The following notes are samples from an article by E. Walter Maunder one of the foremost of modern English writers on astronomical themes:

THE SUN.

In the twelvemonth ending September 30, 1904, the Sun has shown a steady amount of spot activity, without any rapid or marked increase. Indeed, much the greatest single outburst of the period occurred at its commencement, early in October, 1903. Several fine groups were noted during November and December, 1903, and again in April, 1904, but on the whole there has been nothing to call for special notice. This feeble development of spot activity had been anticipated by several experienced solar observers. M. Angot, at the British Association meeting, 1904, contributed a paper in which he showed from an examination of Wolf's sunspot numbers that a feeble minimum was usually followed by a feeble maximum, a relation to which attention has been previously called by other workers in the field. As the minimum of 1901 was small, M. Angot suggested that the next maximum would be small also. On the other hand, the prediction has been hazarded by Dr. W. J. S. Lockyer that the approaching maximum will be unusually well defined, recalling the great one of 1871; such a pronounced maximum being due on his theory of a 35-year period of solar activity.

DEMONSTRATION OF THE SOLAR ORIGIN OF MAGNETIC DISTURBANCES.

That the solar action does, as a matter of fact, take place in definite directions has quite recently been demonstrated by the writer, in the following manner. Tabulating the disturbances recorded from 1882 to 1903 at Greenwich of more than 20 inches in declination, and computing the heliographic longitude of the center of the Sun's disc, for the time of the commencement, it was seen at once that certain disturbances recurred with the return of the same solar longitude to the center of the disc. Indeed, out of 276 disturbances tabulated,

more than three-fourths fell naturally into sequences of which the individual members were separated from each other by a synodic rotation period of the Sun, or by multiples of it. It follows from this relation that the cause of the disturbances must be in the Sun, and in definite, limited areas of its surface. Further, the mode of the solar action must be quite unlike the radiation of light and heat; that is to say, an equal radiation in all directions; but must be confined to quite narrow and sharply defined stream lines. This result entirely alters the light in which we have to regard our magnetic disturbances, and is likely to produce a revolution equally great in our conception of the nature of sun-spots.

Eros and the Sun's Distance.

A reduction by Mr. Arthur R. Hinks of 295 photographs of Eros, made at nine observatories during the period, 1900, November 7-15, gives the value of the solar parallax as 8″.7966, with a probable error of 0″.0047, a result agreeing remarkably well with the value found by Sir David Gill from his heliometer observations of minor planets, namely, 8″.802.

Jupiter.

An important and much-needed investigation on the orbits of the satellites of Jupiter has been carried through by Mr. Bryan Cookson. The observations of the satellites were made with the heliometer of the Cape Observatory at the oppositions of Jupiter taking place in 1901 and 1902. From these Mr. Cookson finds the reciprocal of the mass of Jupiter as 1047.67, a value differing considerably from Newcomb's namely, 1047.35. He also finds corrections to the elements of the orbits of the satellites.

The International Photographic Catalogue.

This great enterprise, undertaken seventeen years ago, is now beginning to show signs of approaching completion. Potsdam has already produced three volumes of its catalogue; Greenwich Observatory has published one volume covering one half of the section allotted to it; the observatories of Helsingfors and of the Vatican at Rome, have also each published one volume; and the observatories of Paris and of the French Colonies have commenced publication.

Gravitation.—In the article by Mr. Cordiero in the January number of Popular Astronomy, I was most impressed by the great amount of essential knowledge which he assumed to be past finding out. In my studies in natural law, I have found many principles and propositions which serve as rational keys for unlocking so called mysteries. The greater of these could never be reached in a life-time of ordinary inductive process. Great discoveries can only be made by broad speculation, deduction and final testing by comparative phenomena.

Let me submit a few of the propositions which I have found useful in developing a rational knowledge of the essential interests of mankind and of a real synthetic philosophy.

First:—Let us recognize a basic universal substance, filling all space, out of which all forms of matter are evolved and concreted, and give this primal substance the arbitrary name of Magnetism for convenience.

Second:—That all matter is inspired and governed by a prime impersonal consciousness or intelligence, out of which all conscious entities are evolved.

Third:—That all matter is in continual activity and forever acting according to laws of consciousness.

Fourth:—That all bodies of organized matter are in a continual state of vibration and radiation.

Fifth:—That the law of attraction and repulsion of matter is the reverse of the theory of Newton, though his mathematics were correct.

Sixth:—According to the above, all matter is in a state of repulsion, disintegration and radiation. This radiating action of matter may be called Magnetic Force.

Seventh:—Every body of matter which lives or grows, like a plant or an animal, possesses a vacuum principle by which it attracts and absorbs such forms of magnetism as have an affinity for it. This negative vacuum power of attraction, we call electricity.

Eighth:—The magnet of physics is any body of matter which is deficient in some substance which belongs to it and, therefore will attract such substance until the vacuum condition ceases.

Ninth:—The degrees of fineness of matter between those recognized by the chemist and the basic substance or magnetism are practically numberless; hence there is but one element in nature.

Tenth: All phenomena is either magnetic, electric, or electro-magnetic; that is, matter is either radiated from its source, attracted by a vacuum or circulates by affinity between positive and negative bodies.

Eleventh: All bodies are positive when they radiate more than they absorb, and negative when they absorb more than they radiate. Among other distinctions, we find that anything that gives us a heating or stimulating effect is magnetic or positive, and anything that gives a cooling or quieting effect is negative or electric.

Twelfth:—Every living body radiates more or less of the finer forms of magnetism about itself which may reach to indefinite distances and carry with them more or less of the consciousness of the body, as observed in telepathic phenomena.

Thirteenth:—The foregoing gives the most rational solution of the motion of the Earth about the Sun; the Earth, instead of revolving upon its axis, revolves upon the Sun's magnetic periphery where the repulsion of the Earth's magnetism equals that of the Sun's magnetism. The distance the Earth moves in a day, divided by the ratio between circumference and radius will give the distance between the Earth and the circle of contact.

Fourteenth:—While the repulsive magnetic radiation of the two bodies keeps the Sun and Earth crowding apart, the vacuum or electric principles of the two growing bodies, draw them together to that circle where the two forces equalize.

Fifteenth.—The Earth is a growing body, born in some way out of its parent orb the Sun; attracts through its atmosphere the trajected matter from dead and decomposing planets called comets, and will continue to do so until in time, itself will become dead, its electric property weaken, its radiation and disintegration become rapid, its orbit become erratic and so continue, until, like the lost Leonids, it ceases to exist and its matter becomes absorbed in new worlds.

Sixteenth:—Each human life corresponds to the Earth's existence. Nature provides and anticipates by law for every natural step of its course. It is conceived and born; it lives, grows, dies and disintegrates, and lastly resolves into such forms of magnetism as can be again caught and absorbed by new entities of vegetable or animal life, while its intelligence becomes merged in the universal consciousness.

JOHN E. AYER.

1725 BELMONT AVE, SEATTLE, WASH.

Schiaparelli on the Astronomy of the Old Testament.—The famous astronomer, Giovanni Schiaparelli of Milan has written a book entitled

L'Astronomia nell' Antics Testamento, which is just now of considerable interest because of the many questions arising on account of the explorations being made and the recent research in Bible antiquities from other scholarly sources.

We have not yet seen this new book, but judging from the tone of the religious press in reviews of it, the book must be a rare contribution to present day literature that will find many readers in America who are equally interested in the present progress and relation of scientific and religious thought in some of their prominent phases which this book discusses apparently in a strong and an independent way. We hope to have a careful review of the new book soon for our own readers.

The Royal Society Medals for 1904.—In looking over the *Scientific year book* for 1905, we find the following awards of medals from that society for the year 1904.

The Copley medal to Sir William Crookes, F. R. S., for his long continued researches in spectroscopic chemistry, on electrical and mechanical phonomena in highly rarefied gases, on radio-active phenomena, and other subjects.

The Rumford medal to Professor Ernest Rutherford, F. R. S., for his researches on radio-activity, particularly for his discovery of the existence and properties of the gaseous emanations from radio-active bodies.

A Royal medal to Professor William Burnside, F. R. S., for his researches in mathematics particularly in the theory of groups.

A Royal medal to Col. David Bruce, B. M., M. C., F. R. A. S., for service in medical lines.

The Davy medal to Professor William Henry Perkins, Jr., F. R. A. S., for his discoveries in organic Chemistry.

The Darwin medal to William Bateson, F. R. S. for his contributions to the theory organic evolution, etc.

The Sylvester medal to Professor George Cantor for his researches in the theories of aggregates and of sets of points of the arithmetic Continuum, of transfinite numbers and Fourier's series.

The Hughes medal to Sir Joseph Wilson Swan for his invention of the electric incandescent lamp and various improvements in the practical applications of electricity.

THE ASTRONOMER. (C. A. Y.)

The destined course of whirling worlds to trace,
To plot the highways of the universe
And hear the morning stars their song rehearse,
And find the wandering comet in its place;
This is the triumph written in his face
And in the gleaming eye that read the Sun
Like open book, and from the spectrum won
The secrets of immeasurable space!

But finer was his mission to impart
The joy of learning, the belief that law
Is but the shadow of the power he saw
Alike in planet and in throbbing heart—
The hope that life breaks through material bars,
The faith in something that outlives the stars.

NEW YORK *Sun*. ROBERT BRIDGES.

Elements of Analytic Geometry by Smith and Gale.—The Yale University series of text-books in mathematics that are now being published by Messrs. Ginn & Company will attract attention widely because of the thoroughness and the modern scholarship that is being put into them. In the November number of this magazine we called attention to Granville's Calculus, and now we have before us the second volume of the series, which has the title, "Elements of Analytic Geometry." This new book is written by P. F. Smith, Professor of Mathematics in the Sheffield Scientific School of Yale University, and A. S. Gale, instructor in mathematics in Yale College. It is plainly intended as a drill book in the elements of Analytic Geometry, and the authors evidently know what students really need from their own experience as teachers in college and university lines of work. The book is quite complete in itself, having a review chapter in Algebra and Trigonometry, at the beginning, readily at hand when needed. The second chapter is on Cartesian coördinates with illustrations of the squared paper to be used in making the graphs to a scale of the simplest figures. Also directed lines are fully illustrated at the close of this chapter, so that a student need not be confused in regard to this important function in analytic work. The curve and the equation is the next chapter, and it is a strong one. It is well planned, and well thought out, abundantly illustrated with exercises and typical graphs.

Chapter IV, in a similar way, takes up the straight line and the general equation of the first degree; then follows the circle and its general equation, leading up to the thought of a system of circles, and so on through each of the conics. The idea of generalizing to a system of curves from the detailed study of a single one of the same family is a good one, and so far as we have noticed in other late books quite new. The way polar coördinates are presented is very complete and highly satisfactory.

Chapter XIII on Euclidean transformation with application to similar conics opens a field of very special interest. Doubtless many teachers of the elements of analytics will make a study of these transformations and their graphical meaning in a way that is new and very useful. The ordinary student finds these transformations in ordinary text-books the dryest and most uninteresting of all his study. This new text gives an improved method of presenting this theme, that seems really attractive to an experienced teacher.

The same can be said, and more, about Chapter XIV which treats of Inversion. The single illustration of inverting an equilateral hyperbola and getting the Lemniscate of Bernoulli, would surprise any student or any teacher the first time he did it.

Plane analytics is presented in fifteen chapters covering 324 pages. Then follows a full treatise on the analytics of space. This part is given in nearly one hundred pages more. The three pages of half-tone plates of the Ellipsoid and other related figures are beautifully clear as illustrations are very helpful to assist the meaning of verbal statements. As a complete book in the elements of Analytic Geometry this new book must stand among the first of its kind. It contains work enough for a college or university class to keep them busy for a whole year, if it should be done well in all its parts. We fear this will be its drawback for very general adoption. Colleges and universities can not give so much time to this one branch. If the scientific schools give less time to all the topics here offered, we are sure some will be slighted.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the tenth of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription are sent directly after the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal promptly as this publication will not be continued beyond the time for which it has been ordered.

Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time.

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should order them when the manuscript is sent to the publisher. They cannot be furnished later without incurring much greater expense.

Subscription Price to Popular Astronomy in the United States, Canada and Mexico is $2.50 per volume of 10 consecutive numbers. Price per volume of 10 numbers to foreign subscribers $3.00. Postage will be accepted only in payment of bills of fifty cents, or less.

All correspondence and all remittances should be sent to

WM. W. PAYNE,
Northfield, Minn., U. S. A.